AGRICULTURAL ENGINEERING

APRIL • 1951

Air Flow Through Inlets Used in Animal Shelter Ventilation *H. V. Walton, D. C. Sprague*

The Application of Ultraviolet to Poultry and Livestock *R. S. Sheetz*

The Effect of Perforations on Flow into Drain Tubes *Don Kirkham, G. O. Schwab*

The Chemical Composition of Hay in Barn Drying *R. B. Davis, Jr., V. H. Baker, et al*

Protection from Grounding Electrical Farm Equipment *N. E. Macpherson*

A.S.A.E. Annual Meeting • Houston, Texas, June 18-20

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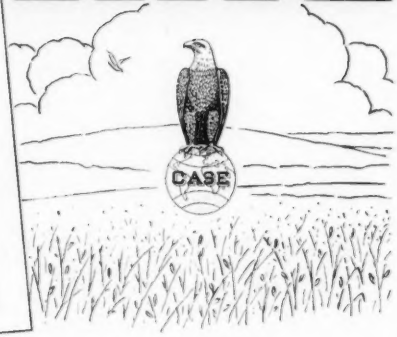

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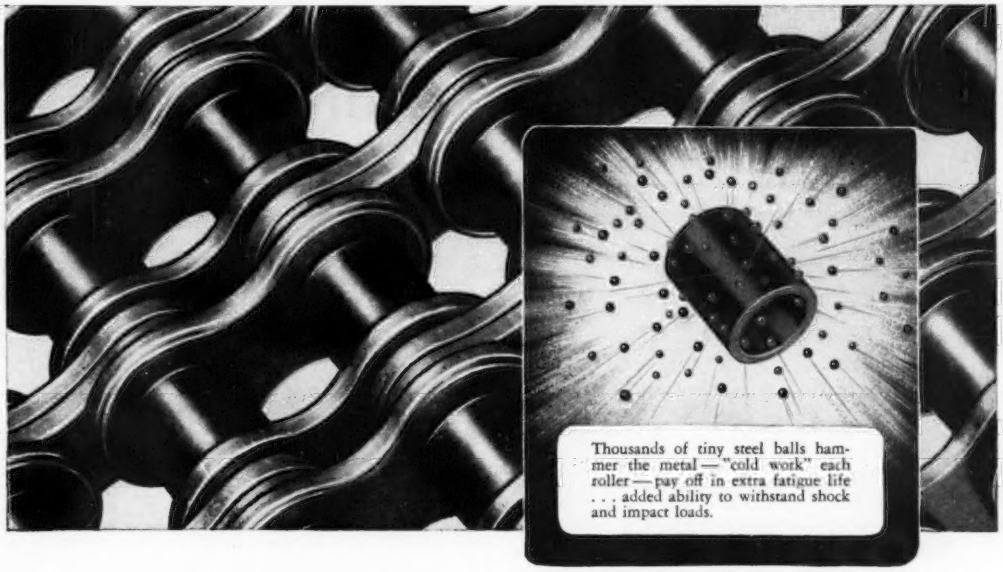
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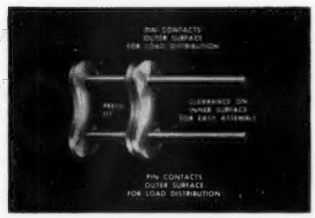
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Established 1920

CONTENTS FOR APRIL, 1951

Vol. 32, No. 4

EDITORIAL 201

AIR FLOW THROUGH INLETS USED IN ANIMAL SHELTER VENTILATION 203
By H. V. Walton and D. C. Sprague

THE APPLICATION OF EXPERIMENTAL DEVIATIONS TO DAIRY STABLE VENTILATION 206
By H. N. Stapleton

ENGINEERING PERFECTION VS. PRACTICAL COMPROMISES IN DAIRY BARN VENTILATION 207
By Nolan Mitchell

THE APPLICATION OF ULTRAVIOLET TO POULTRY AND LIVESTOCK 208
By R. S. Sheetz

THE EFFECT OF CIRCULAR PERFORATIONS ON FLOW INTO SUBSURFACE DRAIN TUBES 211
By Don Kirkham and G. O. Schwab

DEVELOPMENT OF A HIGH-SPEED PLANTER 215
By J. G. Futral and R. L. Allen

A NEW HITCH FOR REAR-MOUNTED TRACTOR EQUIPMENT 216
By E. V. Collins

CHEMICAL COMPOSITION OF HAY IN BARN DRYING 218
By R. B. Davis, Jr., V. H. Baker, P. H. Reaves, J. F. Eheart, and W. N. Linkous

GROUNDING OF ELECTRICAL FARM EQUIPMENT 221
By N. E. Macpherson

NEWS SECTION 226

PERSONNEL SERVICE BULLETIN 242

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Aetna Ball & Roller Bearing Co. 200
American Steel & Wire Co. 234
American Zinc Institute 236
Armco Steel Corp. 239
Austin-Western Co. 237
Blood Brothers Machine Co. 197
J. I. Case Co. 2nd cover
Chain Belt Co. 195
Clark Equipment Co. 233
Electric Wheel Co. 244
Fafnir Bearing Co. 194
Firestone Tire & Rubber Co. 196
French & Hecht Div., Kelsey-Hayes Wheel Co. 240
Hyatt Bearings Div., General Motors Corp. 231
International Harvester Co. 191
International Nickel Co. 241
Johns-Manville Corp. 243
Link-Belt Co. 189, 229
Mechanics Universal Joint Div., Borg-Warner Corp. 202
Morse Chain Co. 198, 199
New Departure, Div. of General Motors Corp. 3rd cover
Oberdorfer Foundries, Inc. 193
Portland Cement Assn. 232
Rochester Mfg. Co. 228
Spraying Systems Co. 240
Stow Mfg. Co. 230
Stran-Steel Div., Great Lakes Steel Corp. 192
The Texas Co. 235
The Timken Roller Bearing Co. 4th cover
The Torrington Co. 227
Tuthill Pump Co. 242
Vickers, Inc. 242
Wisconsin Motor Corp. 238

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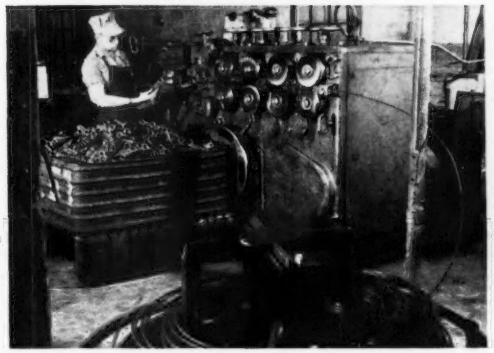
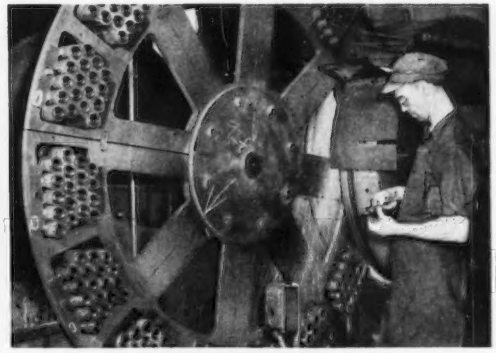
Why IH springs stay lively longer

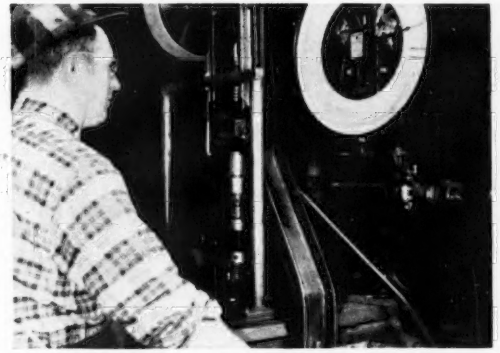
A report to you about men and machines that help maintain International Harvester leadership



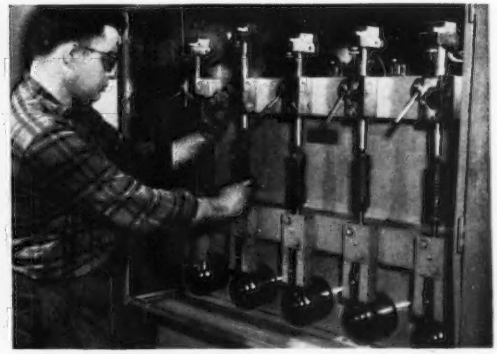
Automatic coiler "hatches off" 10,000 springs a day. It is one of many automatic machines that coil more than 5,000 different springs for IH products. These high quality extension and compression springs are made from thread to finger-size wire. They are as thin as 1/16 of an inch . . . as thick as five inches . . . as short as 1/4-inch and as long as five feet!



"Ferris wheel" ride makes springs act alike. A slight difference in length makes a big difference in the performance of the same spring. That's why the length of valve springs may vary only a few thousandths of an inch. Here are 288 corn planter springs riding the "ferris wheel" through a big grinder which makes them all *exactly* the same length.



Every valve spring must prove its strength. After IH springs have passed many gauging tests during manufacture, they are subjected to a load test—forced to confess their true strength on the scales. Their strength must not be more than five percent above or below normal. The scales themselves are checked for accuracy by their manufacturer every month.



Millions of "push-ups" test valve spring stamina. This valve spring tester, which simulates actual engine operation, compresses valve springs millions of times. When this fatigue test is completed, the length and compression of these springs is double checked. They must not shrink in length or load beyond the rigid standards to which they are designed.

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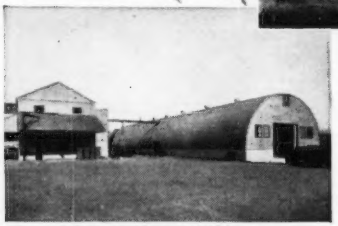

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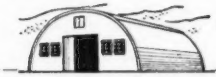

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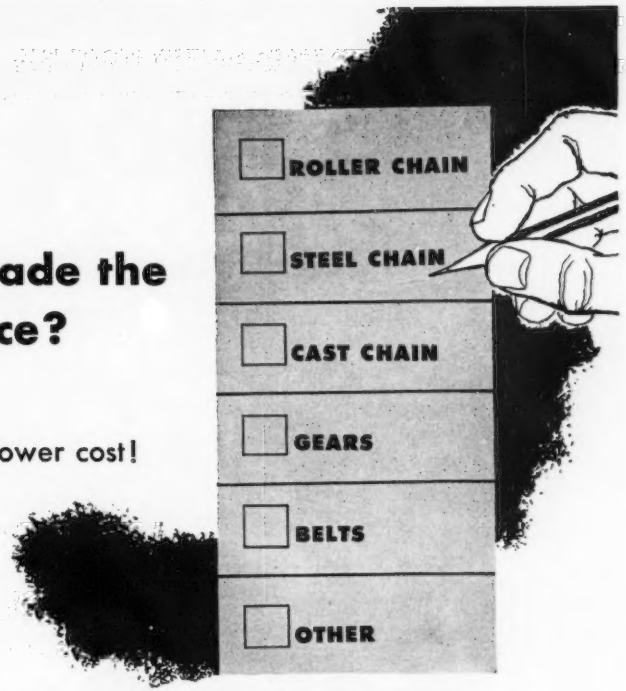

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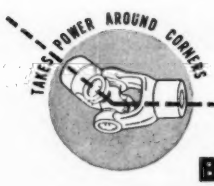

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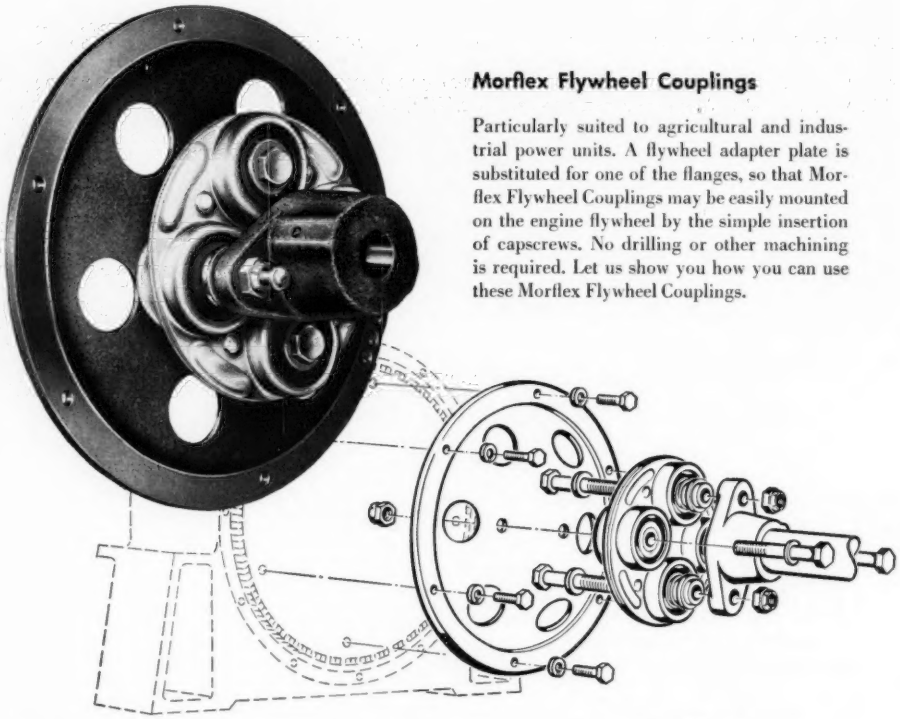

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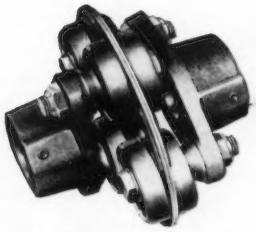

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EDITORIAL

Biology and Engineering

IN THEIR research, development, and applications work some agricultural engineers develop a keen perception of the remaining unknowns limiting their progress. Sound technical work tends to clarify the limits of related knowledge, and to show what further knowledge may be most worth seeking.

One agricultural engineer recently gave us the privilege of reviewing some of his thoughts on remaining unknowns and needed research, developed through years of research in the fields of electricity and of organic processes.

Briefly, his work has developed in him an appetite for increased knowledge of electrophysical, electrochemical and bioelectric relationships.

Electrical energy relationships have been demonstrated, not only in atoms and molecules, but within and between living cells. The significance of this electrical energy occurring naturally in living tissue and resulting biological products is a comparatively new field of study. Likewise the effects of electromagnetic and electrostatic fields, electrical currents, and related phenomena as applied environmental influences on living organisms and organic materials.

It may seem that professional biochemists and biophysicists will be best equipped technically to pursue further knowledge in these fields. That will be true to an extent yet to be determined, but not to the exclusion of agricultural engineers.

The pure science approach of many biochemists and biophysicists can and will be aided and supported by the applied science approach of agricultural engineers seeking facts directly related to agricultural production, handling, processing, and preservation of organic products for human use. Combination of the pure and applied science approaches has generally proven most productive of new knowledge.

There are no fixed boundaries to the dimensions, energies, materials, or other physical properties subject to physical principles or their application by engineering methods. In dealing with the almost infinitely small and numerous, the physicist and engineer have long since by-passed the living cell to analyze and utilize the structure and energies of the atom. In dealing with the almost infinitely complex they have developed computing machines possibly comparable to the complexity of a living organism. From the standpoint of their technology, methods, and interest in agriculture, there is every reason why agricultural engineers might be as interested in intra and intercellular structures and energies as they are in cultivators, combines, or cow barns.

Appreciation of Production

IN RECORDING the culture and events of our times, historians are beginning to note that something significant has been happening in American agriculture within the past century.

From their present mid-twentieth century viewpoint it begins to look like something akin to the industrial revolution in England a few centuries ago, which they have so well noted. They are beginning to take more than a casual look at steps in farm mechanization and related developments.

Men concerned primarily with current production find little direct incentive to record the history of their operations. The recording of history, however, is of current importance far beyond the small place which history books occupy among items of commerce. In connection with agricultural progress as a continuing development, historians can do an important public relations job for all of the contributing factors.

Populations of all types, from bacterial to human, by their very existence and activities set up conditions unfavorable to their further development. In the United States today one of these unfavorable conditions for the human population is public ignorance of some of the main features of its increasing complexity, from an historical perspective.

Large sections of our population share our relatively high prosperity without realizing that they are enjoying more material advantages than the billions of their predecessors down through the ages, without knowing why they are fairly well off, and apparently without any idea that continued and increasingly high productivity is important to their continued material welfare.

The historians of progress in agriculture, its service industries, its sciences, and agricultural engineering can do much to further public appreciation of the importance of high productivity, particularly in agriculture. This in itself would be favorable to continued effective work by these groups.

These historians have not enjoyed uniformly wholehearted cooperation in making old records available for their work. It will evidently be to our interest, and a public service, to help them do a good job of reporting this important phase of modern history.

American Way Pilots Wanted

FOR a constructive thought on how older men can help to keep America in the main channel of the American way of doing things, we are indebted to J. B. Fisher, a member of ASAE for the past 20 years. He sizes up the situation as follows:

> "This country needs, as never before, the guidance and counsel of men of mature age who have had time to read, to observe, and to think.
>
> "If you are on the retired list, no matter where you live, you can perform a service to your country in giving publicity to sound convincing papers, addresses, and discussions on our American way of life. And especially to set the record straight as regards the mumbo jumbo about the impending change in our social order, etc., etc. . . ."

In Waukesha County, Wisconsin, Mr. Fisher is one of a group which encourages discussion of American conditions based on sound information, and sees that this information is readily available in libraries, the local college, and public schools. His recommendation carries the conviction of personal experience.

Defense Organization

CONSIDERATION of the contribution agricultural engineers might make to national defense has led to the development of some tentative conclusions which may be stated briefly as follows:

1 The defense organization needed is an organization in depth, from the front lines back through every element of the supporting civilian economy.

2 A man's value to defense organization in depth may depend a great deal more on his being assigned to duties he is well qualified to perform than on his nearness to the front or on his military or civilian status.

3 Practically every form of human knowledge, skill, and ability is potentially useful to our defense organization in depth. Specialization in human activities and accomplishments has advanced to such a point that various groups of specialists themselves have the best knowledge of the things they can do which might prove of value to the national defense. It is important that groups of specialists make known their special abilities, in order that mobilization agencies may integrate them into a flexible plan for strong over-all defense organization in depth to meet changing defense requirements.

4 Shifting of men to new locations and new work assignments inevitably involves considerable lost motion. Men already engaged in work important *(Continued on page 225)*

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AGRICULTURAL ENGINEERING

VOL. 32 APRIL, 1951 No. 4

Air Flow Through Inlets Used in Animal Shelter Ventilation

By H. V. Walton and D. C. Sprague

ASSOCIATE MEMBER A.S.A.E. MEMBER A.S.A.E.

ONE of the controversial points with regard to present-day, forced-air-ventilation installations is the amount and nature of inlet area to provide. One 60-sq-in inlet for every 3½ animal units is a common recommendation as set forth in college extension circulars and commercial literature. This is the same recommendation as was made for the early gravity system of ventilation and is being applied without modification or change to forced-ventilation systems. This is being done in spite of the fact that increased amounts of air movement are being recommended. Some recent recommendations call for no inlets. The claim is that natural cracks and crevices provide sufficient draft-free infiltration. Field observation of inlet performance has added to the confusion. In a single installation it is probable that some inlets will be discharging, some will be acting as inlets, and some may be stagnant. In the next moment it is probable that their action may be entirely different. It becomes evident that there is no real agreement as to what inlet requirements are.

Agricultural engineers have been unable to meet the inlet problem on an engineering basis. They have found it necessary to work with experience as their only guide. Results have not been satisfactory. Because of the importance of the inlet problem and in an effort to provide some information basic to the design of inlet systems, a study was started late in 1949 to determine inlet air-flow characteristics.[1]

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1950, as a contribution of the Rural Electric Division. Authorized for publication January 12, 1951, as paper No. 1646 in the Journal series of the Pennsylvania Agricultural Experiment Station.

The authors: H. V. WALTON and D. C. SPRAGUE, respectively, assistant professor and professor of agricultural engineering, Pennsylvania State College, State College.

[1]Walton, H. V.: Air Flow Characteristics of Fresh Air Inlets Used in Animal Shelter Ventilation. Master degree thesis, graduate school, Pennsylvania State College.

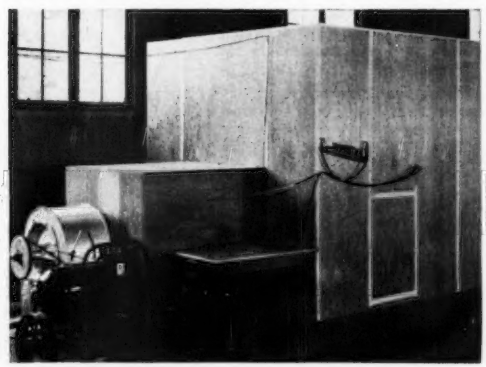

Fig. 1 Equipment and apparatus used to study inlet air-flow characteristics

Test Equipment and Apparatus. The setup required for determining air-flow characteristics of ventilation inlets necessitated a chamber into which the inlets could discharge, a manometer arranged to measure pressure difference causing flow through the inlets, an orifice arrangement to meter the air leaving the stilling chamber into which the inlets discharge, a means of measuring the pressure difference across the orifices, and a fan with provision for moving variable quantities of air. Fig. 1 shows a photograph of the actual test equipment and apparatus, while Fig. 2 shows a schematic view of the arrangement. Inlets under study were mounted in a sheet of plywood which in turn was mounted in the inlet-discharge chamber.

Static-pressure difference across the inlets was measured with a water manometer, selected because of its unique provision for determining water level. It was equipped with a threaded pointer and dial, connected electrically to indicate the moment of contact, which made readings within 0.002 in possible. This precision seemed desirable since the normal pressure range across inlets is so small.

The quantity of air flow through inlets under study was metered with circular orifices having a rounded approach. The following advantages of the circular orifice with a rounded approach led to its selection as the metering device to use. It is easily made; the techniques of its use are simple; it gives the required accuracy, and it has a flow coefficient very near unity which means that even though the coefficient may be incorrectly selected the resulting error will be slight. Only a limited range of air flow is possible with a single size orifice; so four orifices were used in this study to give the range of flow measurement desired.

The quantity of flow through the circular orifice with a rounded approach is determined by calculation after measuring the pressure difference across the orifice. A draft gage was used to make this pressure difference measurement. The draft gage is a sensitive instrument because of its inclined leg and has a scale divided into 100 divisions per inch. In the range of pressures measured, this gave reasonable accuracy.

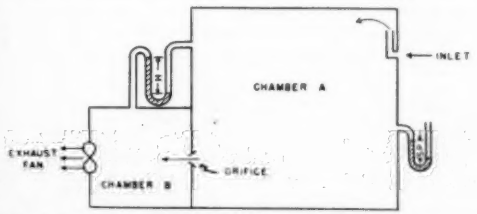

Fig. 2 Schematic view of inlet test arrangement. Inlets under test were mounted to discharge into chamber A which was made large enough so that inlets could be mounted at normal ceiling height. The large size of chamber A also provided for stilling the velocity of air movement through the chamber in order that a true reading could be made of the static pressure *(SP)* causing flow through the inlets. Metering orifices were placed between chamber A and chamber B. Chamber B is a stilling chamber which permitted a good reading of the pressure *(H)* across the orifices

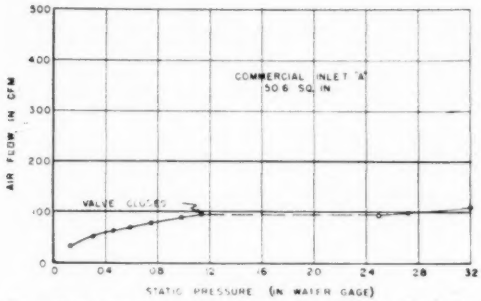

Fig. 3 Flow characteristics for a typical commercial inlet. The broken portion of the curve indicates a pressure range which could not be investigated. The pressure increase resulted from closure of the inlet-flow regulating valve

A centrifugal fan was used in these tests and was driven by an electric motor through a speed changer. Variable fan speed gave control of the pressure difference across the inlets and therefore air flow through the inlets.

Pressure Difference Across Inlets. To select the range of pressure differences important to a study of inlet-flow characteristics, something must be known of the pressure conditions causing flow through inlets in actual installations. Accordingly the pressure difference between inside and outside of several ventilated buildings was checked. This check was made with a water manometer capable of readings to 0.002 inch. One leg of the manometer was open to stable conditions, and the other leg was led to outside conditions by means of rubber tubing. Care was taken to make readings on very still days so that wind pressures would not affect results. Air flow through these buildings was presumably 90 to 125 cfm per animal unit. The results of this study are summarized in the following table:

Barn	Pressure difference, inches of water	Remarks
1	0.025	No inlets
2	0.027	Commercial inlets
3	0.023	Commercial inlets
4	0.020	Commercial inlets
5	0.018	No inlets
6	0.008	Homemade inlets; small fan
7	0.132	High fan volume; no inlets; very tight structure

Barn 7 is included as evidence that such well-built barns do exist. Barns this tight are not common. Further examination of the table shows pressure differences varying from 0.008 to 0.027 in of water. Typical pressure differences would appear to be in the range of 0.01 to 0.03 in of water.

Inlets in service are also subject to the effect of wind, a factor which was considered in selecting a suitable range of pressures for this study. When wind blows against the side of a building, its velocity pressure becomes static pressure which is effective in causing air flow through inlets. A 25-mph wind seemed to be a logical choice for top velocity to consider. This wind velocity has a static pressure equivalent of 0.301 in of water.

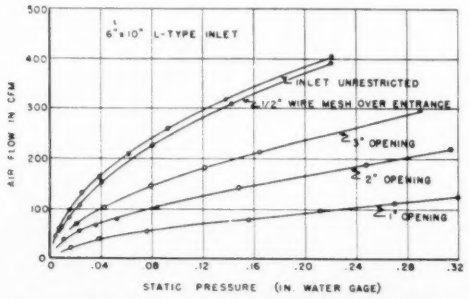

Fig. 5 Air-flow characteristics for a typical 6 x 10-in, L-type inlet

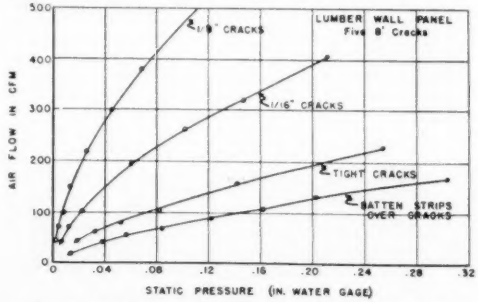

Fig. 6 Air flow through cracks in a rough lumber wall panel

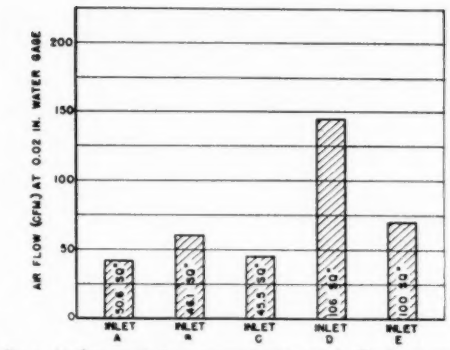

Fig. 4 Air-flow results for commercial inlets tested. The larger rate of air flow through inlet D is a result of its larger cross section and its regulating valve design

Inlet-flow characteristics were investigated over a pressure range from 0 to 0.300 in of water. This gave data to indicate how inlets would respond to higher pressures such as those resulting from winds.

Test Procedure. Each inlet studied was mounted in a panel in the inlet chamber. Mounting instructions or common mounting practice was followed in all cases. As new inlets and panels were mounted, care was taken to seal all seams against air leakage.

With the inlet ready for test and using one orifice (all other orifices closed), the fan was started and adjusted to give a low static-pressure difference across the inlet. Readings were made of this static-pressure difference across the inlet and of pressure difference across the orifice. Fan speed was then increased to give suitable increments of static pressure across the inlet, and necessary pressure readings were made. Additional orifices were opened as required.

Readings of barometric pressure and wet- and dry-bulb temperature were made for each inlet test.

The rate of air flow was calculated for each test point. (For the theory of air flow through circular orifices and methods of calculating the rate of air flow through them, see reference[1].)

Inlet Test Results. Flow characteristics were determined for several commercial inlets having built-in constant-flow features. Several homemade inlets were also investigated. Included were L-type inlets, T-type (overwall) inlets, a stove-

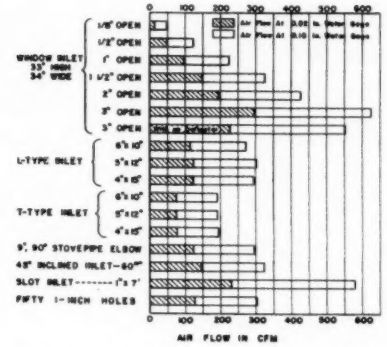

Fig. 7 Air-flow rates at 0.02 and 0.10 in water gage for homemade inlets

pipe elbow, a 45-deg inclined inlet, a tilt-in window, a frame wall panel, a series of 1-in holes, and a 1-in slot.

Fig. 3 shows flow characteristics for a typical commercial inlet. This inlet, along with other commercial units tested, had a built-in valve for regulating the effects of wind. As shown by Fig. 3, the inlet closed off at a static pressure of 0.114 in of water. This pressure is equivalent to a 15.3-mph wind. Also shown is the fact that static pressures above the shut-off point do not increase the flow of air through the inlet any appreciable amount. This means the inlet successfully minimized the effect of winds. Other commercial inlets respond about the same way. Fig. 4 summarizes flow results for the commercial inlets tested. Results are given for a static pressure of 0.02 in of water. This static pressure has been chosen for comparison purposes because it represents very closely the pressure difference across inlets in actual installations. One significant thing in evidence is that commercial inlets admit rather small quantities of air.

Fig. 5 gives air-flow characteristics for a typical 6 x 10-in, L-type inlet. The effect of covering the inlet entrance with hardware cloth is shown, as is the result of closing the inlet varying amounts on the stable side leaving openings 10 in in length. The restriction offered by the hardware cloth over the inlet entrance is not great.

Fig. 6 tells a story about infiltration through cracks in a frame wall. The wall panel tested was 4 ft wide and 8 ft long and contained 5 cracks 8 ft long. It can be seen that cracks admit a considerable quantity of air. One hundred feet of tight cracks (cracks resulting from nailing rough pine boards firmly against each other) will admit as much air as a 6 x 10-in, L-type inlet.

Results of tests with other inlets are given in part by the graph in Fig. 7 which shows air flow rates at 0.02 in and 0.10 in of water static pressure.

Window inlets have not been looked upon with favor, but many people working with animal-shelter ventilation would welcome their simplicity. This led to the study of the wndow as an inlet. Based upon the performance of the frequently recommended L-type inlet, windows 34 in wide and opened more than 1 in at the top offer too little restriction. Without a deflector a window may easily misdirect air. A deflector directing air upward reduces the window inlet capacity but may eliminate drafts. A 34-in window opened 1 in and equipped with a deflector should be equivalent to a 60-sq-in, L-type inlet in performance.

Results of tests with L-type inlets indicate that air-flow rates are not materially different for the three cross-sectional dimensions being recommended. This is further strengthened by results with T-type inlets.

The 9-in stovepipe elbow and the 45-deg inlet were tested because they are being used. They admit slightly greater volumes of air than are admitted by L-type inlets.

Long slots or a series of holes sometimes are used as inlets to admit fresh air from storage spaces or closed-in areas above animal shelters. They admit more air per unit area than other inlets. This means they offer less restriction to the effects of wind. This is not important, however, because they are installed to admit fresh air from wind-sheltered spaces.

It is evident through all of these tests that none of the common inlets admit a very large quantity of air. Based upon present recommendations for size and number of inlets required for animal shelters, a very large percentage of the fresh air entering an animal shelter must of necessity come through cracks.

DISCUSSION AND CONCLUSIONS

1 Typical pressure differences resulting from exhaust-fan action and causing air flow through inlets in Pennsylvania barns when outside air is still lie between 0.01 and 0.03 in of water. A greater pressure difference may exist when the structure is unusually tight. This pressure difference depends upon the amount of inlet area, including cracks, and the rate at which air is being exhausted. Pressure differentials common to various types of construction and for different exhaust rates need further investigation.

2 A tilt-in window opened 1 in or less and provided with a deflector to direct air to the ceiling will give performance equivalent to that of a standard L-type inlet in admitting air. No comparison was made between window inlets and standard inlets with respect to back-drafting due to differences in air density.

3 Changing the cross-sectional dimensions of L-type or T-type inlets within the recommended limits of 4 x 15 in, 5 x 12 in, and 6 x 10 in does not make any appreciable difference in the quantity of flow through these inlets under similar pressure conditions.

4 Placing a ½-in-mesh hardware cloth over an L-type inlet entrance reduces air flow about 15 per cent at the usual operating pressures. Since an inlet entrance is not subject to clogging by dust and chaff, the restriction offered by the ½-in screening should not become greater through service.

5 The T-type inlet admits 60 to 70 per cent as much air as an L-type inlet of equal cross section under similar pressure conditions.

6 The 9-in stovepipe elbow used as an inlet and the 45-deg inlet made of rough lumber and having a 60-sq-in cross section, admit slightly more air than the L-type inlet at a given static pressure difference.

7 Structural cracks admit an appreciable amount of air. One hundred feet of crack, made by fitting rough pine boards firmly against each other, admit volumes of air equal to that admitted by a standard L-type inlet.

8 Long slots or a series of holes admit more air per unit area than any regular inlet.

9 The constant flow feature of available commercial inlets tested limits the effects of wind, but at ordinary operating pressures these inlets admit less air per unit area than do unrestricted inlets.

10 Results of this study show that inlets admit only a small percentage of the air entering an animal shelter. About 20 to 30 per cent of the air enters a stable through L-type or T-type inlets under the usual pressure differences observed, and the balance of the air must enter by infiltration. This is based upon the recommended practice of installing one inlet for each 3½ animal units and upon an air movement of 125 cfm per animal unit.

11 When a condition such as wind velocity causes an increase in pressure difference across an inlet, the rate of air flow through the inlet increases. Winds may or may not strike an inlet with full impact. In fact, wind blowing against a building actually may produce negative pressure areas around corners and on the leaward side. Increased pressure differentials such as may result from winds affect the flow through crack area in about the same way as they affect the flow through installed inlets. The chief difference is that the increased flow through construction cracks is distributed over a larger area.

The Application of Experimental Deviations to Dairy Stable Ventilation

By H. N. Stapleton
MEMBER A.S.A.E.

NEITHER the title nor the content of this paper is meant to be presumptious but rather to report the conscientious effort of one individual in his attempt to correlate some of the current data and recommendations in this field. The seemingly wide divergence of recommendations on the basis of cfm (cubic feet per minute) per cow is the result of the selection of different basic conditions by the separate authors in the solution of the same basic problem of heat transfer. If these recommendations are confusing to farmers, dealers and manufacturers of your acquaintance, just imagine yourself in front of a class of senior agricultural engineers who have been taught by their instructors in basic science and engineering that all is simplicity once a condition can be reduced to an equation.

The fundamental difficulties in basic information seem to lie in our inability to evaluate properly some of the factors in the heat-moisture equation. One is the probable or possible vapor transfer through the walls, ceilings, and floors, which can be shown by calculation under certain conditions to approach one-fourth of the total vapor load. With bank barns which have certain types of masonry in the retaining walls, these earth banks can pass both heat and vapor into the building space, requiring and permitting increased air-volume recommendations for the removal of the moisture load. The cinder or concrete-block wall presents still another problem, in that under certain conditions it will pass water vapor but will not readily permit air infiltration in the manner which certain wood-framed walls provide. The fill-insulated frame wall poses still another problem, for without vapor seal it develops one set of vapor-flow conditions, while the insertion of vapor seal in the "approved" manner defies both vapor transfer and air infiltration.

Another imponderable develops because the conditions imposed on the heat-moisture problem require that a "steady state" must exist. I know that this is disposed of mathematically by making delta time an instantaneous period. But the heat production of the animals is cyclic, with the low as with fasting metabolism, while the high is an unknown figure developing out of heat of feeding and the lactation process. It is perhaps very fortunate that the morning period of high heat production usually slightly precedes and then overlaps the normal daily minimum temperature which occurs just before sunrise. Thus the average indoor temperature is not inclined to follow the outdoor with a lag which would become typical for the building, and any calculated steady state is made practical, either with a "flywheel" of indoor temperature change, or with a "snubber" of high cfm per cow. This is the essential difference between the Vermont-Cornell and the Penn State recommendations. Both are undoubtedly correct as practical solutions for their respective areas, with the more southerly area having the higher mean daily temperature through the critical ventilating period, while northern New York and Vermont are shown in the ASH&VE Guide to be in the —20 F design belt. Penn State also uses this practical solution for the heat conservation provided in a bank barn, together with the vapor transfer into the structure whenever the stable temperature drops below the temperature of the earth bank. It thus appears that this factor evaluates at about the equivalent of 40 cfm per cow on the basis of the difference in results reported between the two areas. Experience in our area (Massachusetts) seems to indicate about this same figure for the difference between the wood frame barn and a block masonry or vapor sealed wall under operating conditions.

Now I am prepared to question the cfm per cow in favor of Barre and Sammet's air flow per total sensible heat, even though you can count the cows while you must estimate the total heat and the percentage split between sensible and latent. I favor the Barre and Sammet* figure because it permits a definition of the problem in more appropriate form for applying judgment, and because if you actually check your calculation from the empiricals, you will have used this relationship anyway. I find Barre and Sammet's total building loss per degree Fahrenheit per total sensible heat a little more definite and descriptive than Strahan's AC†, because it prevents "hiding" 1500-lb Holsteins in 3-ft stalls to the obvious advantage of the air-flow calculation.

It seems obvious that some reasonable evaluation of the effect of a curtain of cold inlet air against the building wall is about due. Sufficiently turbulent or at some velocity, this causes mixing to occur where condensation cannot be produced on a surface, it changes the condition of wall temperature difference, and it produces an effect on the film coefficient of the interior wall surface, all to the benefit of the problem, but still somewhat of a mathematical imponderable. Vermont uses this effect induced by infiltration. Cornell has gone to some trouble to provide a slot from the hay mow plenum to produce this effect. In our poultry house work we assist it with a short ceiling curtain. It seems to be helpful, but it is definitely unevaluated, in its effect on heat conservation and control of condensation. In reporting test work it is mentioned sometimes, but in any event it insidiously affects the results, with further divergence of empirical recommendations.

There are limits in the application of ventilation which ought to be noted because they help to define the problem. As an empirical it can be noted that under most conceivable conditions 40 cfm per cow, give or take 3 cfm, will always move the moisture. It can be noted that with a 50 F temperature differential between indoors and outdoors, the calculable sensible heat is about used up in warming the ventilating air necessary for moisture removal, and therefore a wall which loses no heat at all, while unattainable, is still not good enough. At the other extreme, as the outdoor temperature approaches the maximum permissible indoor temperature, air flow by any calculation, and with most equipment, becomes an unattainable volume; so you open the doors and windows and hope that the calendar and the grass in the pasture show that your next concern with ventilation will be due to summer heat.

All such empiricals permit a quick check on the more complete calculations. Among the rather convenient ones is the ASH&VE Guide's equation for the air flow required for heat removal. While this provides a figure slightly in excess of that produced from Barre and Sammet's chart for the same assumed temperatures, it produces a total cfm value quickly without the interpolation of cubic feet per pound of air from the psychrometric chart. So we all use empiricals, one way or another, to save work, to check results, and to eliminate unknown or unrecognized factors in our problem.

As if there weren't enough unknown or variable basic factors in this problem already, Giese, Downing, and their co-workers now add the heat exchanger. This unit with its heat regain should assist in the solution of the insulation and condensation factors, particularly in the colder areas. Penn State will probably use it to heat the milkhouse. Others will use it to dry out the barns. Certainly a device which is capable of the regain of 40 per cent or more of the sensible heat

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*Barre and Sammet: Farm Structures, John Wiley and Sons.

†J. L. Strahan: A Method of Designing Insulation and Ventilation for Animal Shelter Buildings, AGRICULTURAL ENGINEERING, vol. 26, October, 1945, page 407.

production of the animals is a worth-while addition to the ventilation layout. It will provide some problems in developing the details of application, but it should definitely solve more problems than it adds.

It is interesting to note, however, that the recommendations from the Iowa tests do not seem to correlate with airflow figures which are obtained by applying other methods. Air flow on the basis of the tabulated data using the ASH & VE Guide formula indicates the airflow to be too low to keep the barn temperature from rising above those noted, and using Barre and Sammet's indoor temperature for the corresponding outside temperature, 150 to 180 per cent of recommended air flow is indicated in the range of the mean daily outdoor temperature. It appears that the use of the heat exchanger will not be a substitute for the calculation of the heat-moisture flow problem, and the application of judgment by the designer to each specific problem.

The use of the heat exchanger can also bring up again the whole problem of fan applications. The velocities needed for efficient heat exchange and for throwing the warmed inlet air; the need for some arrangement of balance between inflow and outflow to help counteract or induce infiltration, and the possibility of reversing the inflow fan to assist in the removal of heat and moisture during warm weather, without the necessity of opening windows and doors and thereby taking the ventilation off automatic control, all point to the necessity of reexamining fan characteristics which will decide the selection required for this service.

CONCLUSION

It should be noted that only the selection of the values of the basic factors in the ventilation problem are different, when another individual attacks a specific problem. The problem and the results desired may be essentially the same. The cost factor enters the picture at some point and tempers the tolerance of the amount of condensation which will be permitted; and from that point the divergence of recommendations develops. As usual, the standard of perfection attainable is closely related to the amount of money which is considered available. In this case it must be spent for insulation, a heat exchanger, or for supplemental heat, depending on the degree of perfection desired and the severity of the climate, all depending on the degree of tolerance of the amount of condensation.

Engineering Perfection vs. Practical Compromises in Dairy Barn Ventilation

By Nolan Mitchell
ASSOCIATE MEMBER A.S.A.E.

IF COWS came equipped with defrosters, dehumidifiers, no-draft ventilation, windshield wipers, fog lights and umbrellas, winter weather conditions in the barn would present no problem. But since they do not, we should ask ourselves these questions. Is the barn foggy on cold days and muggy on warm days? Are the inside walls wet or covered with white frost? Do the windows have to be opened to give the cows fresh air? Are the window sills rotting and the stanchions rusting? Do barn odors creep into milk or make the barn unpleasant in which to work? If the answer is yes to any or all these questions, then it is time to do something about the weather in the barn!

To successfully regulate barn temperature and humidity three important steps must be taken: Air must be moved continuously around cows and calves; all windows and doors must be kept closed to keep livestock free from drafts, and an air regulator—thermostatic temperature control—must be installed. To understand why three, and only three, facts must be evaluated, consider the condition affecting the design and installation of an electric, automatic barn-ventilating system. Your cows will heat the barn, your barn will retain the heat, and an electric fan of the proper size will mix the air with the heat, thus absorbing the moisture given off by the cows, and a thermostatically operated temperature control will tell the fan when and how much air to move out of the barn.

These are the winter weather conditions which agricultural experiment stations and dairy barn ventilation engineers recommend for milk cows: (a) A moisture condition not to exceed 75 per cent relative humidity, (b) an air temperature from 45 to 50 F, and (c) an air supply that is constantly fresh. When these conditions are met, costly deterioration of buildings and equipment is avoided and the herd's health is safeguarded.

Ventilating fans must meet certain specifications on a per cow basis. During the winter days, when the outside temperature varies from 10 F to —10 F, the fan should have provisions for dampering the air output to 40 cfm or less per cow. Such an arrangement makes it possible to have some air flow at all times and yet avoid undesirable low temperatures in the barn. The ventilating fan should be regulated by an automatic thermostat so that during a January thaw, when the temperature may jump from 0 to 40 F in a few hours, the fan increases the air flow to its maximum capacity to keep the barn temperature from going above the desired temperature. The maximum capacity of the fan required depends on the maximum barn temperature desired at a given outside temperature. For example, if a maximum barn temperature of 50 F is desired when the outside temperature is 35 F, the fan should have a maximum capacity of 120 cfm per cow. If the same barn temperature is desired at an outside temperature of 40 F then the maximum capacity of fan must be 250 cfm per cow.

In addition to meeting the above requirements and being especially designed for moving air out of dairy barns, our company's ventilating fans feature a totally enclosed motor built for continuous duty; have self-cleaning, sparkproof, rustproof, non-overloading blades; are equipped with thermal overload switch to protect against motor burnouts, and are also equipped with accurate, rustproof, air-control thermostat to keep the right amount of air moving out of the barn 24 hours a day as long as the cows are in the barn.

When planning a barn ventilation system, consider the dairy barn and the milk cow as two separate units. The cow is a heating unit and the barn is a heat storage unit. When the heat supply and the heat storage facilities are in balance during the winter period, a properly planned and installed ventilation system will keep the barn temperature at 45 to 50 F and the relative humidity at 75 per cent.

As a heating unit, the cow, a Holstein weighing approximately 1250 lb, for example, furnishes 3500 Btu per hr. These Btu must be sufficient to vaporize the moisture from respiration, urine, and droppings, furnish the heat required for ventilation, and furnish the heat required to replace heat losses through walls, windows, doors, and roof of the dairy barn. In addition, we expect the cow to fill the milk pail twice daily. Whether she can efficiently serve as a heat and milk producer depends upon how well we balance the three heat factors outlined.

A simple, step-by-step procedure for planning a successful ventilating system for all dairy barns is, first, to assume the dairy barn has an inside exposure area of 140 sq ft — a common practice. Second, assume the heat losses through walls, windows, etc., as 0.25 Btu per sq ft per hr per deg difference between outside air and air inside the dairy barn. Then the dairy-barn heat loss per cow per degree temperature difference is 140 x 0.25 x temperature difference. *(Continued on page 210)*

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The Application of Ultraviolet to Poultry and Livestock

By R. S. Sheetz

THE sun sends out radiations of various wave lengths visible to the human eye as light of different colors, ranging through the spectrum from red, the long wave lengths, to violet the short ones. We cannot see the very longest radiations, the infrared, but we feel them as heat. Nor can we see the shortest or ultraviolet rays. However, it is these radiations which produce the greatest physiological effects on humans and animals.

Sunlight ultraviolet has long been known to cure rickets, for these are the radiations which are necessary for the assimilation of calcium and phosphorous. Thus ultraviolet radiations are of prime value in the development of strong and sturdy bones, whether it be in a chicken, calf, or human.

The development of rickets has usually been attributed to a lack of vitamin D, and it is well known that vitamin D will cure them. However, it is also known that sunshine supplies animals with other benefits which are now under investigation, but no one knows exactly how these benefits are derived.

Fortified feeds containing vitamin D and other necessary minerals and vitamins show even better results when the animals are raised in the presence of sunshine. By themselves, the feeds do not seem to do the best job of which they are capable.

In addition to the systemic effect of sunshine there are certain diseases which appear to develop more rapidly in an absence of sunlight. For instance, sarcoptic mange is most prevalent among cattle in the wintertime, but clears up in the spring and summer when they are turned out in the pasture. Feathering of poultry often is poorer, as well as the color of the legs and comb, when the birds are out of sunlight. Often with broilers, a scaly condition will develop on their legs which reduces their sale value, and, at present, sunlight seems to be the only thing which will improve this condition.

The use of artificial sources of sunshine ultraviolet has long been advocated because it most nearly duplicates the natural action of the sun. As long ago as 1930, lamps producing these radiations were used advantageously with animals. Since that time many different types of sun lamps of varying output and wave length have been developed which can produce some of these desirable effects, but all have been so expensive to buy and use that their application has been extremely limited. With the recent development of the low-cost fluorescent sun lamp which, like sunlight, produces a continuous type of radiation spectrum, this picture has been completely changed, so that now a convenient and economical means is available to bring the benefits of sunshine ultraviolet to animals all year round.

With laying hens, ultraviolet radiations have been found to increase production and develop stronger egg shells, as can be seen from the following cases in which fluorescent sun lamps were installed over laying hens.

In the first case two pens were used, each of which contained about 700 birds. All conditions were identical, except that pen No. 1 was equipped with five 20-w fluorescent sun lamps, and pen No. 2 was not.

The trial was conducted from January 1 to January 19, 1950. Prior to that time the production of both groups had been about the same. In pen No. 1, 682 hens produced 8,486 eggs for an average of 12.44 eggs per hen, while in pen No. 2 688 hens produced only 6,483 eggs for an average of 9.7 eggs per hen. Thus in this 19-day period, the pen having the fluorescent sun lamps had 28.8 per cent more productivity and it was reported that the quality of the eggshell was greatly improved.

Similar effects are described in another installation in Escondido Valley, California. In this case the birds were housed in one building having four separate rows of birds. Five 20-w fluorescent sun lamps were installed over the second row in such a way that the radiations were shielded from the birds in the other three rows. A daily count of egg production began on January 1, 1950, and was continued through March. The results are as follows:

ACTUAL COUNT OF EGGS LAID PER ROW BY MONTHS

	Row 1	Row 2 Fluorescent sun lamps	Row 3	Row 4
Month of January, 1950	4804	5371	4900	4888
Month of February, 1950	4699	5404	5062	5054
Month of March, 1950	4331	5071	4891	4801
Total	13834	15846	14853	14743

These figures show that over the 3-month period, the birds under the sun lamps produced 1370, or 9½ per cent, more eggs than the average of the other three rows. Here, too, as in the previous example, the operator reports stronger eggshells.

Artificial illumination on time-clock control was used in this poultry house prior to the installation of fluorescent sun lamps and was continued without change throughout the test. Thus the effect of the ultraviolet rays was to increase production beyond that obtained by extending the chicken's day through the use of artificial illumination.

In another installation in Madison, Wisconsin, where fluorescent sun lamps are installed over 2500 layers, the poultryman has reported better coloring of the comb and improved all-around appearance. Shell texture has been improved to such an extent that on the last count only 7 eggs out of 490 dozen were rejects, whereas previously an average of 22 dozen eggs were rejected for every 600 dozen produced.

It is significant to note that standard vitamin-D-fortified feed was used in all these tests. Thus increased production was obtained in spite of the fact that the birds received the normally accepted quantity of vitamin D. This seems to indicate that the favorable effect of ultraviolet on poultry is brought about by some factor other than the production of vitamin D.

The recent announcement of tests conducted over a 5-year period by the U.S. Department of Agriculture at Beltsville, Md., confirms this. The Department of Agriculture's work showed that chickens exposed to the ultraviolet rays of germicidal Sterilamps layed 10 to 19 per cent more eggs than those not exposed. In these tests, birds were fed high concentrations of vitamin D which were far more than they could use, and still the ultraviolet was responsible for increased production. Thus the Department of Agriculture concluded that the beneficial effect was not the result of the vitamin D content of the light rays, but that some other effect was involved. Just what properties of the ultraviolet light caused the increase have not been identified.

The 10 to 19 per cent increase in production realized in the Department of Agriculture's tests agrees closely with the results obtained previously by private growers. Widespread experience with sun lamps in poultry establishments has also shown that birds exposed to these radiations are healthier, have brighter colored combs and shanks, and improved plumage.

Experimental work at various agricultural experiment stations in the past has proved that sunshine ultraviolet rays also increase growth rate, increase the hatchability of eggs, result in the production of larger and stronger pullets, and eliminate rickets. These effects have always been considered to be the result of vitamin D production within the bird itself.

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Recently we have received preliminary reports from broiler growers using the fluorescent sun lamp, which indicate that these lamps are improving the feed conversion of the birds. One such test conducted at Preston, Md., on 2500 birds and which lasted 11 weeks, 3 days, showed that birds under the sun lamps used 2.97 lb of feed per pound of meat, whereas those not under the lamps required 3.10 lb of feed per pound of meat. It is believed that the difference would have been even more striking but for the fact that the birds all had colds originally and got off to a poor start.

Word from another installation in Plainview, Tex., shows similar results. In this broiler test 3000 birds were raised under the lamps. Unfortunately there was no control group, but the broilerman reported that after 8 weeks the birds consumed only 160 bags of feed, whereas it previously took 210 bags to bring the birds through 8 weeks.

These results indicate a better assimilation of the specially balanced, high-quality feeds now on the market, but further work is under way to establish the exact effect of sunshine ultraviolet rays on feed conversion.

The benefits of sunshine ultraviolet radiations for livestock are fundamentally similar to those for poultry. Faster growth rate and stronger, healthier animals are reported. Appearance is also improved because of a better, shinier coat of fur.

While the value of ultraviolet to mature animals is readily discernable through improved appearance and health, the effects are probably most apparent with younger growing animals which are in the formative stage. At this time animals need all their strength to aid in their growth, and sunshine ultraviolet radiations assist in providing this.

Typical of the effects of these radiations on animals is the experience of farmer Arthur Ghent of Castle Creek, N. Y. Last winter Mr. Ghent was having trouble with a litter of newborn pigs. All exhibited strong signs of rickets and were not growing properly. A 20-w fluorescent sun lamp was installed over the pigs and within a week they were completely cured and, according to Mr. Ghent, they grew faster and stronger than previous pigs not exposed.

Another striking instance of the value of these radiations is given by a farmer who installed a fluorescent sun lamp over three calves. Before using the lamp, one calf, of registered stock, was in such a weakened and poor condition that it was questionable whether or not it would live. The two other calves, although not as unsound as the registered calf, were in a very weakened condition and their development was considerably below normal. Upon using the sun lamp, a rapid improvement in their condition was seen, and they quickly gained in strength and weight.

The savings realized by the farmers in these two examples who, without the aid of the sun lamp, would have lost a good part of their investment, dramatically demonstrate the economic importance of sunshine ultraviolet radiations to animal growers.

From the foregoing it can be seen that sunshine ultraviolet is a powerful tool which the farmer can use to improve the health of his animals, but obviously it must be justified from an economic viewpoint for the increased income it can bring. During the past 20 years, there being general recognition of the value of sunshine, sun lamps were tried several times by the poultry-raising industry, but because of unsatisfactory economic considerations with the lamps available, these attempts met with only short-lived success. The high initial cost, short life, and large amounts of electric power required made previous sun lamps so expensive to use that neither large nor small animal producers were able to justify their use.

This condition has been completely changed by the development of the fluorescent sun lamp, for this lamp is highly efficient and costs little to use. Looking just like any regular fluorescent lamp in appearance, it has been designed to produce the biologically-active ultraviolet rays of sunshine instead of visible light. It has the same characteristic advantages of the fluorescent lamp, which include long life, low wattage, and broad and uniform radiation coverage.

As with any fluorescent lamp, the fluorescent sun lamp requires certain auxiliary equipment and for best effects should be used with a polished metal reflector. Typical of the units now being made is a fixture manufactured by the J. T. Sexton Co. of Kansas City, Mo. The 20-w size is recommended for poultry and smaller animals. The Alzak aluminum reflector has been specially designed to efficiently direct all the radiations downward to the desired area.

To be effective, the ultraviolet energy must strike the animal directly just as natural sunlight does. Therefore, with poultry, the fixture should be positioned so that all the birds in the flock come under the lamp at some time while it is operating. Often this can best be accomplished by locating the lamp over or close to the feeding trough and operating during feeding time. By so doing, the random movements of the poultry will be sure to bring all within the irradiated area.

One 20-w unit in a reflector is generally sufficient for irradiating a flock of layers in a house of up to 400 sq ft of floor area. The unit should be suspended about 6 ft over the feeding trough and operated throughout the day. Where more than one lamp is used in a pen, they should be placed over different feeding troughs or uniformly distributed so that as great an area as possible is covered.

Fig. 1 *(Left)* These Berkshire hogs receive the beneficial ultraviolet radiations of sunshine even during the winter months from the Westinghouse fluorescent sun lamp suspended above them • Fig. 2 *(Center)* Ultraviolet radiations from a sun lamp supplement balanced, vitamin-enriched poultry feed, keep the birds virtually ricketproof and help them to grow faster and lay more eggs • Fig. 3 *(Right)* These calves receive 24 hr of sunshine as they bask in the beneficial rays of scientifically balanced sunlight. Tests indicate that animals exposed to the ultraviolet of sunlight are healthier and stronger than those deprived of it (Photos courtesy of Westinghouse Electric Corp.)

For livestock such as cows or horses confined indoors in box stalls, adequate coverage of two stalls can often be effected with one 40-w fluorescent sun lamp mounted about 6 to 8 ft above the floor. This mounting height provides enough clearance so that there will be no interference when feeding the animals. Animals confined in barns where they are kept in alleys and fed from continuous troughs usually can receive adequate coverage from one 40-w lamp installed for each three animals. In any case, an all-day exposure is recommended. With cows, the lamps can be turned on at milking time in the morning and off at milking time at night.

The 20-w lamp is used where it is not necessary to cover as large an area, as for instance in a pig brooder where a sow and a litter may be confined in an area of 8 to 10 ft square. Here, too, it is recommended that the lamps be operated continuously throughout the day.

So far we have confined our discussion principally to the sunshine ultraviolet produced by sun lamps, but now let us consider another type of ultraviolet—germicidal ultraviolet.

GERMICIDAL ULTRAVIOLET LAMPS OFFER ADVANTAGES

You will recall that sunlight is composed of many radiations, the shortest of which are the ultraviolet which produce the physiological effects on animals just described. While ultraviolet radiations of shorter wavelength do not appear in sunlight, they can be produced easily by special lamps known as germicidal lamps. This has been an important step forward by science, for these radiations are lethal to all germs and microorganisms known to man, and can therefore be used to reduce the spread of sickness or contagious diseases. For years they have been used in hospitals to reduce the danger of transmission of disease, or the infection of wounds during operations. Many industries, such as meat packing, pharmaceutical, baking, beverage, and other food-processing plants, rely on them to maintain sanitation of products and prevent contamination and spoilage. Many installations made in schools and offices during the past 10 years clearly demonstrate their ability to reduce sickness and protect people from cross infection.

Animals, like people, are susceptible to diseases that are transmitted by air-borne germs, and germicidal lamps may be successfully used where animals are housed, to destroy disease-producing germs which float in the air and which can cause epidemics. The following is typical of the results obtained with germicidal ultraviolet in reducing sickness and mortality in a hatchery. The lamps were installed in houses containing 12 to 14 thousand day-old chicks, which were kept for 6 weeks. Ninety-eight per cent control of colds and coryza was approached, and this hatchery, which incidentally brooded over 5,000,000 chickens in a four-year period, reports a steady drop in brooding losses from year to year. In fact, the losses in one of their plants have run as low at 4½ per cent, which they consider exceptional for sexed, mass-production chicks as they come from the incubators and sexers.

Experience with hundreds of installations in laying houses has also shown that as well as reducing sickness and mortality among the birds, the rays from germicidal lamps increase egg production. As previously mentioned, this has recently been confirmed by the U.S. Department of Agriculture in Beltsville, Md., which found that hens exposed to germicidal lamps lay 10 to 19 per cent more eggs. The increase in productivity is not believed to be associated with the germicidal properties of the rays.

These lamps are also used in stables and pens to protect horses and livestock from cross infection by air-borne bacteria. Many kennels and animal farms also employ them to protect dogs, mink, fox, and other small animals from respiratory diseases which often develop as a result of the high contamination of bacteria in the air where conditions are crowded.

The germicidal lamp best suited for use with animals is the 17-w cold cathode lamp in a direct-radiation fixture. The units are generally mounted on the ceiling so that the rays can come down directly into the area occupied by the animals.

The cold cathode type of lamp is recommended over other lamp types because it is the most economical to use, and because its output is very constant throughout its entire 12,000-hr life. Actually, based on a 3-cent kilowatt-hour and continuous burning, the cost of the lamp and power is less than 4 cents a day. Lamps of the hot cathode type last only a third as long, and, what is more objectionable, have a very high initial output. This latter factor is very undesirable since, unlike sunlight ultraviolet, germicidal ultraviolet radiations are exceedingly effective in irritating the eyes. Thus, with too high a germicidal ultraviolet intensity, the animals' eyes will become irritated and they will become listless and stop eating. Because of the hot-cathode lamp's very high initial output when new, it is exceedingly difficult to directly irradiate the animals without burning their eyes, and then there is trouble from insufficient ultraviolet when the lamp is old. This, in fact, was the reason the Department of Agriculture used cold cathode lamps in their test work, for when they tried hot cathode lamps they burned the birds.

In laying houses where germicidal lamps are used to foster egg production as reported by the Department of Agriculture, one 17-w cold cathode lamp is generally adequate for up to 400 sq ft of floor area. However, when dealing with brooder and broiler plants where not only the physiological benefits are important, but the germicidal effect is equally desirable for reducing epidemics and cross infection, more lamps are required, the number varying and depending upon the conditions.

I would like to explode one big fallacy which has existed for some time in connection with the use of germicidal lamps with poultry, namely, that dust might be prevalent in some poultry houses which would reduce the lamp output so as to make it impractical. Statements have even been made by some people having no experience in the use of germicidal lamps with poultry, that the lamps have to be cleaned at least once a day to be effective. This is completely false, for tests have shown that under ordinary conditions lamps need only be wiped about once a month with a damp cloth. Under severe dusty conditions the wiping may have to be more frequent, perhaps twice a month.

In the foregoing, I have reviewed briefly the effects and usage of ultraviolet in the poultry and livestock industries. With the development of the new highly efficient fluorescent sun lamp and the improvement in life and efficiency of the cold cathode germicidal lamp, the use of ultraviolet to protect animals from disease and bring them the benefits of sunshine all year round will become more and more widespread. These two lamps are but one more example of industry's continuing progress to provide new and improved methods for increased farm production and profit.

Dairy Barn Ventilation

(Continued from page 207)

Infiltration of cold air around windows, doors, etc., may be estimated and added.

As an illustration, if the outside temperature is 30 F and the desired inside temperature is 50 F, the cow, which is the barn's heating unit, must supply the building heat losses if a barn temperature of 50 F is to be maintained. The building loss per cow per hour is 700 Btu. The cow must also supply heat to warm the air from 30 to 50 F so the air will absorb the moisture. The heat required for ventilation is 1710 Btu. In addition to supplying heat to replace building losses and for ventilation, the cow must also supply body heat to vaporize 0.93 lb of moisture per hour from respiration, urine, and droppings. The vaporization heat required is 970 Btu. Thus the total heat to be supplied per cow is 3380 Btu, and the total heat made available per cow is 3500 Btu. This is considered a fair heat balance.

When there is no heat balance, the ventilation problem can be solved by (a) adding insulation to bring building heat losses in balance, (b) adding more cows to increase the available heat, or (c) adding both insulation and cows.

The Effect of Circular Perforations on Flow into Subsurface Drain Tubes

Part I. THEORY

By Don Kirkham and G. O. Schwab
MEMBER A.S.A.E.

VARIOUS types of perforated tubing are used for the drainage of earth dams, bridge approaches, or other earth embankments where large pressures are encountered, and have recently come into use in the agricultural drainage of land. Interest in the effect of perforations on drain-tube performance has increased at the Iowa Agricultural Experiment Station in connection with the possible use of a flexible-perforated-thermoplastic tubing which can be pulled into place in a mole channel behind a mole plow. The present paper analyzes the effect of circular perforations on drain-tube performance, the assumption being made that the soil both around the drain tube, and at distances removed from it, is of uniform permeability.

In solving the problem the procedure is as follows: (a) A theory based on Darcy's law is obtained for the flow; (b) using electric-analogue model experiments, the theory is spot-checked; (c) with the theory established, the mathematical formulas which have been developed under (a) are used with confidence to calculate the effect of a wide range of sizes and spacings of perforations and of sizes and depths of drain tubes. In Part I, (a) is developed; in Part II, (b) and (c) will be considered.

Although the theory is rather complex, it is well worth the effort obtained in deriving it, since it not only shows the way in which various factors enter into the problem, but also obviates a large amount of experimentation. Nevertheless, this paper is prepared so that readers not wishing to follow theoretical details may pass to the Summary and then to Part II after consulting Figs. 1 and 2. Fig. 1 shows samples of some types of commercially available perforated tubing to which the results given in this paper will apply. Fig. 2 is a diagrammatic sketch illustrating the problem and showing geometrical quantities involved.

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The authors: DON KIRKHAM and G. O. SCHWAB, respectively, research professor of agronomy and professor of physics, and research associate in agricultural engineering, Iowa Agricultural Experiment Station.

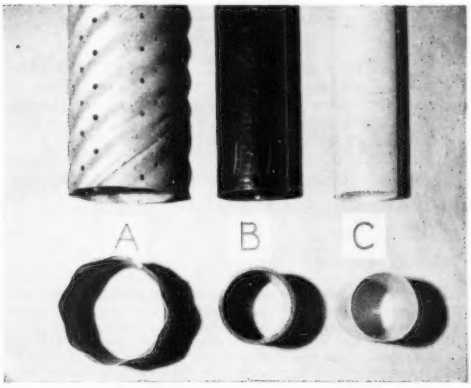

Fig. 1 Types of perforated tubing used in subsurface drainage: A, corrugated metal pipe; B, fiber tar-impregnated pipe, and C, thermoplastic tubing

ANALYSIS

In developing the following analysis it is assumed that the reader is familiar with the methods (see, for example, Muskat's treatise(1)*) for solving ground water problems governed by Darcy's law. Besides the actual drain tube of radius r_w† at depth d below the soil surface, there is an image drain tube at distance d (and radius r_w) above the surface. The purpose of the image drain is to make, analytically, the surface of the soil a plane of equal hydraulic head, for it is assumed that the soil is water saturated to the surface and that there can also be a layer of water of thickness t on the surface of the soil.

The perforations are of radius r_p and lie on m longitudinal

*Numbers in parentheses refer to the appended references.

†The notation in the present analysis agrees largely with that of Muskat (2), his w denoting "well".

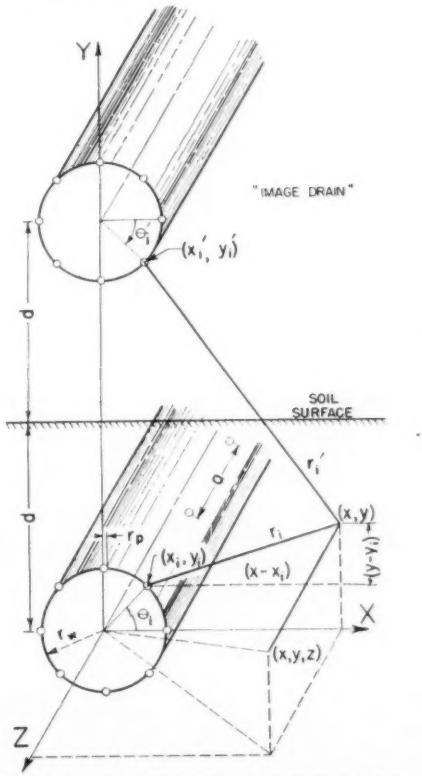

Fig. 2 Diagrammatic representation of a perforated subsurface drain tube and its image

lines, equally spaced about the periphery of the tube. The longitudinal separation of the perforations is a. The location of the perforations is further specified by placing them on equally spaced circles having their centers on the axis of the tube. The origin of rectangular coordinates is taken at the center of one of these circles. The y axis is vertically upward, the x axis horizontally to the right, and the z axis is colinear with the axis of the drain tube. The location of a typical perforation lying on the circle in the (x, y) plane is specified by the coordinates of its center (x_i, y_i), or by the angle θ_i measured from the x axis to a line drawn from the center of the perforations to the origin of coordinates.

Determination of the Hydraulic Head. An expression for the hydraulic head h (h is a potential function) at a point (x, y, z) in the soil is first obtained. With h known, the flow into the perforations can readily be computed. The analytical form desired can be taken basically as that due to a vertical perforated well casing, a form derived by Muskat(2). In the present problem the well casing becomes a horizontal drain tube; an image "well casing", as indicated above, is also required. Muskat assumes that the perforations approximate analytically a series of spherical sinks. This assumption is also used initially here. Later in the analysis it will be shown that the flow values obtained on the basis of spherical sinks must be multiplied by a factor $2/\pi=0.636$ to yield the proper flow for flat, circular openings, as actually found.

Let the projection on the (x, y) plane at the point (x, y, z) (Fig. 2) be distance r_i from the center of the perforation at (x_i, y_i) and let the projection of this same point be distance r_i' from the image perforation at (x_i', y_i'). Then from the figure

$$r_i = \left[(x-x_i)^2 + (y-y_i)^2\right]^{\frac{1}{2}}$$

$$r_i' = \left[(x-x_i')^2 + (y-y_i')^2\right]^{\frac{1}{2}} \quad . \quad . \quad . \quad . \quad [1]$$

Also, it is convenient to define

$$\rho_i = \frac{r_i}{a}\ ,\ \rho_i' = \frac{r_i'}{a}\ ,\ \rho_p = \frac{r_p}{a}\ ,$$

$$w = \frac{z}{a}\ ,\ \delta = \frac{d}{a}\ ,\ \rho_w = \frac{r_w}{a} \quad . \quad . \quad [2]$$

and it is observed from the figure that

$$x_i = x_i' = r_w \cos\theta_i\ ,\ y_i = r_w \sin\theta_i$$

$$y_i' = 2d - r_w \sin\theta_i\ ,\ x_0 = r_w\ ,\ y_0 = 0\ . \quad . \quad [3]$$

Using the above notation one can now write down the potential due to *all* the perforations in two lines of perforations θ_i and θ_i'. This potential h_i is

$$h_i = -\frac{4q}{a}\left\{\log_e\left(\frac{2}{\rho_i}\right) + 2\sum_{n=1}^{\infty}\left[K_0(2n\pi\rho_i)\right]\left[\cos 2n\pi w\right]\right\} + \frac{4q}{a}\left\{\log_e\left(\frac{2}{\rho_i'}\right) + 2\sum_{n=1}^{\infty}\left[K_0(2n\pi\rho_i')\right]\left[\cos 2n\pi w\right]\right\} \quad [4]$$

where K_0 $(2n\pi\rho_i)$ and K_0 $(2n\pi\rho_i')$ are Bessel functions of the second kind and zero order (sometimes also called Hankel functions), defined and tabulated, for example, in the British Association Mathematical Tables(3), and q is a constant, a flow coefficient, to be evaluated. The form of the expressions in brackets in equation [4] differs from the form of Muskat in that a subtractive term $(2n\pi i/m)$ is not included in the argument of the cosine term. This term was used by Muskat because he assumed that the perforations lay on a spiral, whereas they are taken here to lie on equally spaced circles. Muskat showed that the results are for practical purposes the same in either case. The circle case is simpler analytically.

The occurrence of the logarithmic term $\log_e(2/\rho_i)$, and hence of $\log_e(2/\rho_i')$ in equation [4] is explained by Madelung(4)‡ (see especially pp. 525-527, Das Feld einer geraden Punktreihe), from whom the potential form stems. Although in equation [4] the 2's in the numerators of the logarithmic terms can be cancelled, they are preserved to retain the basic potential form. Muskat's q differs from the present q by a constant factor, since he deals with pressures rather than hydraulic heads.

The potential h due to all the m rows of sinks is obtained from equation [4] by summing the effects of the individual pairs of rows, and by adding a term $(d+t)$ which makes $h=d+t$ when $y=d$. This potential is (since $h_i=0$ when $y=d$)

$$h = \sum_{i=0}^{m-1} h_i + d + t \quad . \quad . \quad . \quad . \quad . \quad [5]$$

where the reference level for hydraulic head is taken at the level of the axis of the drain tube, assumed horizontal, and a layer of water of thickness t is assumed to be on the surface of the water-saturated soil. The h_i terms are zero when $y=d$, because of the use of the image drain tube.

The flow constant q is now evaluated. This is done by determining the analytical value of h (say h_w) at a reference point on a perforation and equating this value to the known physical value of h at this point of reference. The known value results from the assumption that the drain is running full with no back pressure, so that the hydraulic head (referred as before to the level of the drain axis) has the constant value r_w everywhere inside the drain tube, and hence has this value r_w at each perforation. Therefore $h_w=r_w$. It is convenient to evaluate h_w at a point on the perforation centered at $(x_i, y_i)=(x_0, y_0)=r_w, 0)$, the coordinates of this point being $(x, y, z)=(r_w, r_p, 0)$. Substituting, then, these values of x, y, x_i, y_i and z in equation [5], one finds with the aid of equations [2] to [4], subject to comments below,

$$h_w = r_w = -\frac{4q}{a}\left\{\log_e\left(\frac{2}{\rho_p}\right) + 2\sum_{n=1}^{\infty}K_0(2n\pi\rho_p) + 2\sum_{i=1}^{m-1}\left[\sum_{n=1}^{\infty}K_0\left(4n\pi\rho_w\sin\frac{\theta_i}{2}\right)\right] - (m-1)\log_e\rho_w - \sum_{i=1}^{m-1}\log_e\sin\frac{\theta_i}{2}\right\} + \frac{4mq}{a}\left\{\log_e\left[\frac{2}{(4\delta^2+\rho_w^2)^{\frac{1}{2}}}\right] + 2\sum_{n=1}^{\infty}K_0\left[2n\pi(4\delta^2+\rho_w^2)^{\frac{1}{2}}\right]\right\} + d + t \quad [6]$$

which may be solved for q.

‡Madelung's E corresponds to the $2q$ used by Muskat. Muskat does not state why $2q$ instead of the conventional q is used. The reason, however, seems to lie in the fact, brought out in the appendix of his article, that the flow into the perforations may be assumed to be not only equivalent to the flow into spherical sinks, but also to twice the flow (nearly) which would pass into hemispherical sinks located at the perforations. These hemispherical sinks are tacitly introduced to account analytically for the physical fact that the well casing is impervious except at perforations, there being accordingly no possibility for flow to enter the halves of spheres on the inside of an impervious tube wall.

In equation [6] the term with coefficient $-4q/a$ represents the effect of the perforations in the actual drain tube. This term can be obtained directly from the right-hand side of Muskat's(2) equation [6] by taking his quantity $\cos 2n\pi\, i/m = 1$, for the reason indicated previously. The term with coefficient $4mq/a$ in our equation [6] is that due to the image drain. The latter term has been determined by assuming that an average value of ρ_i' evaluated at the reference point is $(4\delta^2+\rho_w^2)^{1/2}$, and that, consequently the effect of the m image lines, is merely m times the average value of one of them. For definiteness (as well as convenience) the perforation centered at (r_w, O, O) has been singled out to obtain equation [6], and hence evaluate q. If, instead, the perforation at (O, r_w, O) had been used, a larger value of q would have resulted. Actually an average value of q appropriate for all the perforations is desired. Consideration shows that this average value will be given by equation [6] if ρ_w^2 is dropped compared with $4\delta^2$. An easy way to reach this conclusion is to measure, and then average, all possible distances between the perforations shown on the two large circles in Fig. 2. It will be found that the average distance is very nearly $2d$, the approximation becoming better as $2d$ becomes large compared to r_w. For example, if there are four lines of perforations and d is as small as $d=2r_w$, the average distance referred to is found to be $2.06d$; whereas if $d=4r_w$, the average distance is $2.02d$. The apparent errors, 3 per cent and 1 per cent, are made still smaller by the circumstance that these distances $2.06d$ and $2.02d$ occur in the arguments of slowly varying logarithmic, and Bessel function terms.

Aside from replacement of $(4\delta^2+\rho_w^2)^{1/2}$ in equation [6] by 2δ, the equation may be further simplified by introducing a constant C defined by

$$C = \frac{1}{m}\left\{ 2\sum_{n=1}^{\infty} K_o(2n\pi\rho_p) + 2\sum_{i=1}^{m-1}\left[\sum_{n=1}^{\infty} K_o(4n\pi\rho_w \sin\frac{\theta_i}{2})\right] + \log_e\left(\frac{\rho_w}{\rho_p}\right) - \sum_{i=1}^{m-1}\log_e\left(2\sin\frac{\theta_i}{2}\right)\right\} \quad [7]$$

Using, then, equation [7] in equation [6], noting that for practical cases the K_o terms involving δ are negligible and simplifying and solving for q, there results

$$q = \frac{\left(\frac{a}{4m}\right)\cdot(d+t-r_w)}{C+\log_e\left(\frac{2d}{r_w}\right)} \quad [8]$$

Computation of the Flow. Since q is now known, h is completely determined and the flow Q_S per unit length of drain tube per unit time can be computed. This is done by noting that at all points at the surface of the soil the flow Q_S' per unit area per unit time is vertically downward (the subscript S referring to spherical perforations), and hence, by Darcy's law, is given by

$$Q_S' = K\frac{\partial h}{\partial y}$$

where $\partial h/\partial y$, the hydraulic gradient, is evaluated at $y=d$ and where K (not to be confused with the Bessel function K_o) is the soil permeability. The total flow Q_S entering the drain tube is, therefore,

$$Q_S = K\int_{-\infty}^{\infty}\left(\frac{\partial h}{\partial y}\right)_{y=d} dx \quad [9]$$

In evaluating $\partial h/\partial y$ one makes use of the fact that near $y=d$ the K_o terms in the hydraulic head function h are essentially constant (=zero) compared to the logarithmic terms; and that the derivative of K_o terms are thus essentially zero compared to the derivatives of the logarithmic terms. Therefore, *near* $y=d$, very approximately,

$$h = -\frac{4q}{a}\sum_{i=0}^{m-1}\left[\log_e\left(\frac{2}{\rho_i}\right) - \log_e\left(\frac{2}{\rho_i'}\right)\right] + d + t \quad [10]$$

That is, *near* $y=d$, using equations [1] to [5] in equation [10] and simplifying, there results

$$h = \frac{2q}{a}\sum_{i=0}^{m-1}\left\{\log_e\left[(x-r_w\cos\theta_i)^2 + (y-r_w\sin\theta_i)^2\right] - \log_e\left[(x-r_w\cos\theta_i)^2 + (y-2d+r_w\sin\theta_i)^2\right]\right\} + d + t$$

so that

$$\left[\frac{\partial h}{\partial y}\right]_{y=d} = \frac{8q}{a}\sum_{i=0}^{m-1}\left\{(d-r_w\sin\theta_i)\left[(x-r_w\cos\theta_i)^2 + (d-r_w\sin\theta_i)^2\right]^{-1}\right\} \quad [11]$$

Putting equation [11] in equation [9] and integrating, there results

$$Q_S = \frac{8Kq\pi m}{a}$$

or substituting in this expression the value of q given by equation [8], one finds

$$Q_S = \frac{2\pi K(d+t-r_w)}{C+\log_e\left(\frac{2d}{r_w}\right)} \quad [12]$$

Derivation of the Factor $2/\pi$. The value Q_S so far derived is for spherical sinks and is thus higher than the flow value one would expect to find in practice. Soil is generally not bulged up at drain tube openings. It lies flat over them, or even protrudes inwardly. To take the latter actual situation into account the reasoning is as follows: Muskat(2) showed (see the appendix of his article) that well-casing perforations, although located on an impermeable pipe, nevertheless, behave as if they were an array of spherical sinks located in the porous medium devoid of pipe. Muskat's assumption that the shape of the sinks is spherical is justified in that the perforations of his interest are made by firing bullets into a well casing, a process which opens up porous medium about the perforations. In the present case there is little justification for assuming spherical-shaped sinks. On the contrary, as indicated above, one can conclude that circular plate-shaped sinks are appropriate to the present flow and that a comparison of flow into circular plate-shaped sinks and into spherical sinks should yield the factor sought. Since Darcy's law, Ohm's law, and Maxwell's law, are all analogous, it can be shown (compare Muskat(1), p. 140 with Smythe(6), p. 233) that the electrostatic capacities of two condensers are in the same ratio as are the seepage flows for two analogous ground water

systems. Now the electrostatic capacity for a circular plate of radius r_p in an infinite medium of dielectric constant unity is $2r_p/\pi$ (see Smythe(6), p. 112, equation [2]), whereas the capacity for a sphere of radius r_p in the same medium is merely r_p (see Smythe(6), bottom p. 27, equation [2]). The ratio of these two quantities, $(2r_p/\pi)/(r_p)=2/\pi$, is the ratio sought if it can be shown that the spherical sinks and circular plate-shaped sinks in the actual problem are sufficiently far apart as to behave as if they were infinitely separated. The latter point may be shown as follows.

The electrostatic capacity C_E of two spheres of radius r_p and distance c between centers is given by§

$$C_E = 2r_p \sinh \beta \sum_{n=1}^{\infty} \left[\operatorname{csch} (2n-1)\beta - \operatorname{csch} 2n\beta \right]$$

where β is defined by

$$\operatorname{csch}\beta = \frac{c}{2r_p}$$

Since perforations will generally be at least 5 diameters apart $c/2r_p=5$, $\beta=2.292$, $\sinh \beta=4.897$, $\Sigma=0.1857$ and $C_E=2r_p\times4.897\times0.1857=2r_p\times0.910$. Thus the proximity of the spheres results in a decrease in their capacity of only 9 per cent compared with what it would be for infinite separation. An exact expression for the capacity of a pair of circular plates is not available, but the error due to proximity should be of the same order of magnitude as for spheres. It is concluded then that the factor $2/\pi$ is correct enough for practical purposes. Therefore, writing Q for the flow per unit length into a perforated drain tube having no outward (or inward) bulging of soil over the perforations, the multiplication of both sides of equation [12] by $2/\pi$ yields, since $Q=Q_S(2/\pi)$,

$$Q = \frac{4K(d+t-r_w)}{C+\log_e\left(\frac{2d}{r_w}\right)} \quad . \quad . \quad [13]$$

The flow Q_S and Q of equation [12] and [13] may be compared with the flow Q_o into a completely porous drain tube. A completely porous drain tube is approximated, in practice, by a drain embedded in gravel. This flow Q_o is found to be (see, for example, Kirkham(5), equation [11] where r_w is to be neglected compared to d)

$$Q_o = \frac{2\pi K(d+t-r_w)}{\log_e\left(\frac{2d}{r_w}\right)} \quad . \quad . \quad . \quad [14]$$

Although equation [14] is strictly true, for an impervious layer at great depth (and for spacing of drains large compared to d) the equation is, in addition, very nearly correct for drain tubes located a few drain radii above an impervious layer. Equations [12] and [13] should likewise be true if the drain tube is a few drain radii above an impervious layer.

SUMMARY

It is shown that if the perforations in a drain tube are assumed to be equivalent to spherical openings, the quantity of water Q_S entering unit length of drain tube per unit time is

$$Q_S = \frac{2\pi K(d+t-r_w)}{C+\log_e\left(\frac{2d}{r_w}\right)} \quad . \quad . \quad [15]$$

In equation [15] K=soil permeability, d=depth to center of drain tube, t=thickness of layer of surface water, r_w=radius of tube, C=a constant defined by equation [7]. In equation [7] symbols are defined as follows (see Fig. 2): m=the number of rows of perforations, $\rho_p=r_p/a$, r_p=radius of a perforation, a=distance between perforations, $\rho_w=r_w/a$, $K_o(2n\pi\rho_p)$=Bessel function of argument $2n\pi\rho_p$, n=an integer having values 1, 2, 3, . . ., $\pi=3.14\ldots$, $K_o[4n\pi\rho_w \sin(\Theta_i/2)]$=Bessel function of argument $4n\pi\rho_w \sin(\Theta_i/2)$, Θ_i=angle between the (x, z) plane and the plane passing through the tube axis and a line of perforations at x_i, y_i, and i=an integer having values 1, 2, 3, . . . $(m-1)$. Bessel functions are defined and tabulated in the British Association Mathematical Tables(3). In equation [15] Q_S will be in cubic feet per day per foot of drain tube, if K is in feet per day, and d, t, r_w, r_p, and a are in feet.

It is further shown that the right-hand side of equation [15], if multiplied by $2/\pi$, yields the flow for drain tube perforations when the perforations are assumed to be flat-circular openings in the tube. This flow Q which corresponds more closely to actual field conditions than Q_S is

$$Q = \frac{4K(d+t-r_w)}{C+\log_e\left(\frac{2d}{r_w}\right)} \quad . \quad . \quad . \quad [16]$$

The symbols in the right-hand side of equation [16] are defined, and may be taken to have units, as under equation [15]. Thus Q will be in cubic feet per foot of drain tube per day if K is in feet per day and the other quantities in feet.

The flow Q_o per unit length of completely porous drain tube is (in practice a completely porous drain tube is approximated by a drain embedded in gravel)

$$Q_o = \frac{2\pi K(d+t-r_w)}{\log_e\left(\frac{2d}{r_w}\right)} \quad . \quad . \quad . \quad . \quad [17]$$

where the symbols are as above, Q_o being in cubic feet per foot of drain tube per day if K is in feet per day and the other quantities in feet.

The derivation of equations [15], [16], and [17] are based on the following assumptions: (a) the soil is water saturated to the surface and in addition has a layer of ponded water of thickness t, (b) the drain tubes are running full with zero back pressure or suction, (c) the permeability of the soil is the same whether measured in the horizontal or vertical direction, and whether measured near to or far from the drain, (d) the drains are spaced far apart compared to their depth, (e) an impervious layer is at considerable depth preventing deep natural drainage of the soil. Item (e) will have little effect on the solutions if the drain tube is a few radii above an impervious layer. In addition to the above five items, certain simplifying assumptions in the analysis have been made. For practical purposes, however, the results may be taken as correct.

§See Smythe (6) p. 120, equations (3), (4), and (5), and page 37, equation (1), taking $V_1=V_2=V$, and $Q_1=Q_2=Q/2$, so that $C=Q/V=2(c_{11}+c_{21})=2(c_{12}+c_{22})$.

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Development of a High-Speed Planter

By J. G. Futral and R. L. Allen

EXTENSIVE research on the relationship of peanut-plant spacings to yields was conducted in Georgia for several years. By the end of 1944 it was apparent that yields were increased as the distance between plants lessened. These results led to a recommendation of an optimum seed spacing of 3 in for Spanish peanuts in 24 to 28-in rows, and 5 in for runners when planted in 28 to 36-in rows.

It was found that these stands could not be obtained with the types of tractor-mounted planters generally used if the tractor speed exceeded 3 mph. During the rush of spring planting, speeds of 5 mph are often exceeded in the large level fields of south Georgia. Gearing the planters to a 1½-in spacing did not produce a uniform 3-in stand at speeds above 3 mph.

Investigations showed three reasons for the drop in planting efficiency at higher speeds. These are:

1 The plates of the inclined-cell-plate type were rotating so fast that seed were frequently carried past the drop-out opening.

2 The inertia of the spring-loaded kickout mechanism used on the flat-plate-type planter was too high to function properly and damage resulted to the seed when spring tension was increased.

3 With tractor-mounted hoppers, seed frequently set up a spiralling motion in the round flexible seed spouts thereby delaying the drop and causing bunching by interfering with the following seed.

The National Peanut Council was also interested in this phase of peanut mechanization, and in 1945 work was begun as a joint project of the Georgia Agricultural Experiment Station and the engineering experiment station of the Georgia Institute of Technology. The first step was an effort to increase the efficiency of existing planters. A selection of typical planters was made by I. F. Reed of the U.S. Tillage Machinery Laboratory at Auburn, Ala. Changes in the baffles and drop-out openings resulted in a 4 per cent increase in efficiency which was considered inadequate. Therefore, the use of a different principle was indicated.

Essential features of the principle selected are shown in Fig. 1. A belt perforated by properly sized holes runs at a 45-deg angle through the hopper. Seed fall into the holes and are carried up and out of the hopper. Near the top of the belt path a soft-rubber retaining belt contacts the seed belt and presses against it during the vertical descent, thereby holding the seed in place until the belts separate at the bottom. The action of the seed belt in changing from a vertical to a horizontal position imparts to the seed a positive downward velocity resulting in their being thrown to the ground.

A small model was built and tests showed a high efficiency at the belt speed necessary to obtain a 3-in spacing with a tractor speed of 10 mph. Damage to seed was less than one per cent, although the peanuts used had been shelled six months previously and dried to obtain material which would be easily damaged.

It was found necessary to regulate the depth of seed in the pickup hopper to prevent a crushing action when the belt moved through it. This was simply accomplished by using a large supply hopper with a spout mounted over the pickup hopper. The length of spout regulates seed depth.

Next, a single-row field unit was constructed using the basic frame of a mule-drawn planter with a sword opener and a ground drive. Speeds up to 10 mph were used in planting peanuts with this unit. Stands were uniform and no significant differences were found between stand counts at different speeds, except where a rock or hard spot had been encountered by the opener at the higher speeds. When this ocurred, the planter would bounce, causing a skip varying from 5 to 8 ft. Using this model as a guide, two others were built by Mr. Reed incorporating changes that simplified the drive and belt changing. One of these units contained only a single hopper and was satisfactory for soybeans and other hard seed but did damage peanuts.

Since the original funds were exhausted, the Georgia Engineering Experiment Station decided to finance the construction of the farm-scale unit shown in Fig. 2. The following features are incorporated:

1 The units are tractor-driven instead of ground-driven.

2 Spring-loaded disk openers are used in place of sword openers to absorb shocks and prevent bouncing.

3 The frame is constructed to allow row-width changes in 1-in increments. Simultaneous planting of four rows up to

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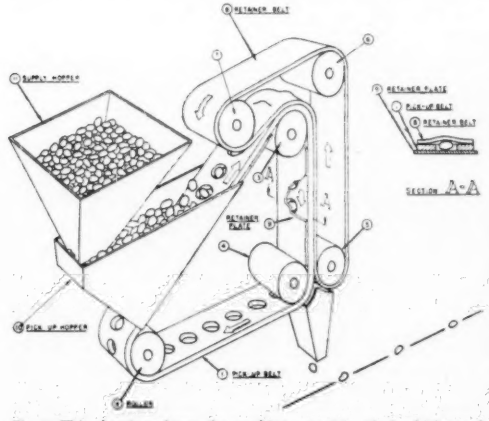

Fig. 1 This drawing shows the working principle of the high-speed planter

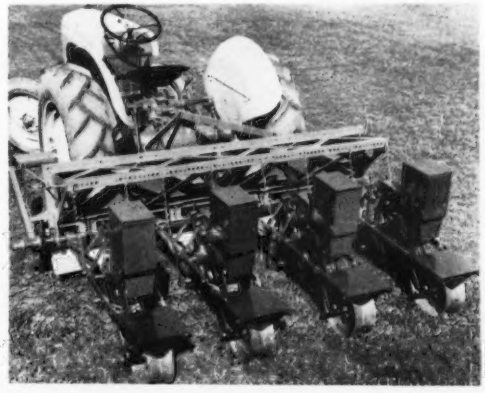

Fig. 2 The multirow field planter used in the planting tests

Fig. 3 *(Left)* Soybeans planted at the speeds varying from 6 to 15 mph. Note the one-foot white marker in lower left of picture • Fig. 4 *(Right)* Closeup of one-foot marker shown in Fig. 3, illustrating the average stand obtained at planting speed of 10 mph

24-in widths, three rows up to 42-in widths, and two rows at greater widths, is possible.

4 An automatic clutch to cut off the planters when raised for turning is provided.

5 Each planter has an independent vertical travel of 10 in to provide for irregular ground.

Uniform 3-in spacing of peanuts was obtained on several soils including rolling land with curved rows. The highest possible speeds were used in the trials ranging from 10 mph on straight rows to 3.5 mph on curving hillside rows.

The unit was tried with soybeans where a 1-in spacing was desired. The Spanish peanut belts were used since it was found that the holes would each pick up three soybeans. At speeds above 4 mph, enough scatter in the row was produced to provide a surprisingly uniform spacing averaging one inch. Admittedly dangerous speeds of 15 mph were reached in this test without affecting stands.

Results of this planting are shown in Figs. 3 and 4. Disk openers were superior to sword openers under the conditions of this trial which was run when the soil was very dry. The disks produced less soil disturbance and better compaction than the sword openers that were used for comparison. Soybeans planted with the disk openers came up to a good stand immediately, while the ones planted with the sword openers were delayed until it rained.

The high speeds previously mentioned were used only for experimental purposes. Speeds ranging from 4 to 6 mph are used in the peanut-growing sections of Georgia when conditions permit, and these seem to represent a practical maximum from the driver's viewpoint. This unit, equipped with row markers, has planted 3 acres per hour with no strain on the driver. Three 28-in rows were simultaneously planted in this trial.

The use of a ground drive instead of a tractor drive would be desirable for simplicity and economy. A comparison of the two drives using different types and mountings of ground traction wheels will be made next year. Other changes which will be tried are remounting to enable the use of larger-diameter disks, and new belt materials. Redesigning to permit rapid belt changes would be another desirable change. At present, this operation requires 20 min per unit. Tests are also planned to determine whether the pickup mechanism will retain its efficiency when used with flat or irregularly shaped seed such as corn and lima beans.

A New Hitch for Rear-Mounted Tractor Equipment

By E. V. Collins

MEMBER A.S.A.E.

THE hitch described in this paper has three features which will be discussed separately.

The first feature affects the steering of the plow to make it operate satisfactorily on curves and to stabilize the width of cut for curves or varied soil conditions. The converging lower links of the standard hitch give a measure of this desired action, but not enough if plowing is to be done on curves or if much change in soil conditions is encountered.

The Ferguson plow has a crankshaft across the frame which can be rotated with a wrench to adjust the width of cut. In the improved hitch a similar crank shaft is mounted in bearings and operated automatically by a connection to a stabilizer bracket as shown in Fig. 1, A and B. This feature allows much shorter turns, gives more uniform width of cut on turns either way and stabilizes the width of cut under varying soil conditions. The rate of response is determined by the relative lengths of the crank arms and the position of the stabilizer bracket.

The second feature is an arrangement to carry part of the side thrust on the tractor. This is accomplished by a spring applied to the crank arm A, Fig. 1, tending to rotate the shaft, and push the plow to the right. In practice as much sidethrust is carried on the tractor as possible without interfering with tractor steering.

This feature is a necessity on a mounted one-way disk if the first feature of the hitch is used. It worked so well on this that it seemed logical to apply it to the plow also.

The third feature is designed to provide proper suction to the plow for all conditions and still utilize the advantages of the rear-mounting linkage. Basically the plow is pulled and lifted from an imaginary line extending crosswise of the plow near the "center of draft" of the plowing unit. This is accomplished by forming the slots A, Fig. 2, so that they describe an arc from the center of draft. Rollers B work in these slots so that there is a limited freedom of the plowing unit to

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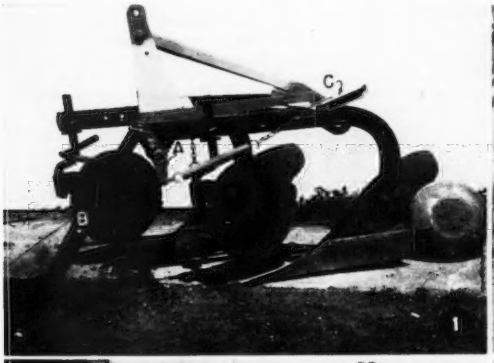
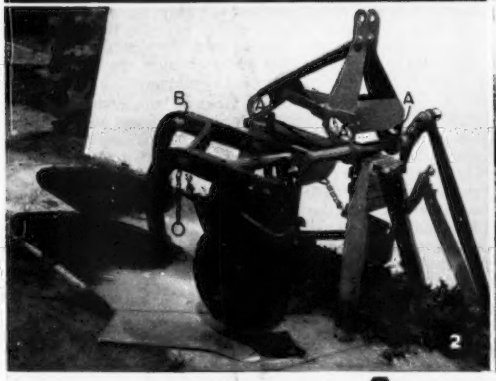
rotate about the center of draft. The suction of the plow is set by adjustment of the rear wheel and the plow enters the ground point first, runs level in operation, and leaves the ground point first. The length of the top link is not critical unless the rollers touch the end of the slots in normal plowing.

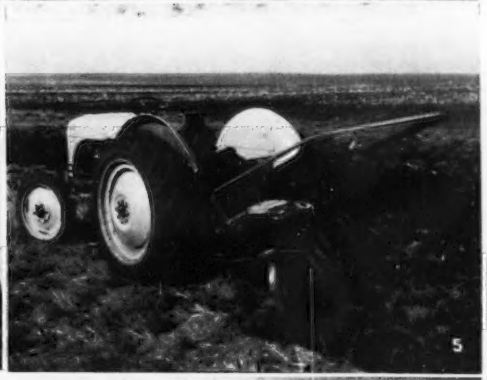
Experiments have been conducted only with tractors having automatic draft control. For other tractors a depth gage wheel or some other means of limiting depth would be required.

With this equipment it is possible to plow 3 in deep without the plow jumping out of the furrow or drop to 10 in and still have plenty of suction to load the rear of the tractor so it can pull the plow. The unit shown is a functional design built for experimental and demonstration purposes and is not intended as a production model.

In addition to the plow and the one-way disk, the hitch has also been applied to a mounted 2-row lister. This provides smooth operation around curves, maintains uniform depth of planting and uniform pressure on covering wheels.







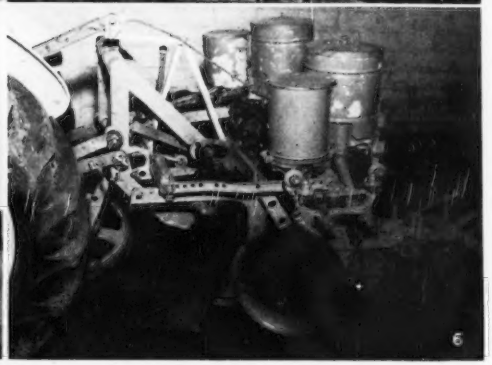


Fig. 1 Side view of plow with new hitch: A, crank arm to provide automatic steering; B, link to connect to stabilizer bracket, and C, toggle lever to release or adjust spring tension • Fig. 2 Hitch disassembled to show slots: A, arcuate slots, and B, rollers which work in above slots • Fig. 3 Right side of experimental unit • Fig. 4 Mounted one-way disk with first two features described, turning to right. Weighted arm used instead of spring • Fig. 5 Mounted one-way disk turning left. Note raised weight arm • Fig. 6 Rear-mounted lister with first and third features of hitch described

Chemical Composition of Hay in Barn Drying

By R. B. Davis, Jr., V. H. Baker, P. M. Reaves, J. F. Eheart, and W. N. Linkous
ASSOCIATE MEMBERS A.S.A.E.

THE question of hay quality arises whenever the subject of barn hay drying is discussed. More specifically, the discussion centers on the question of whether or not hay dried by forced ventilation loses or retains nutrients. In an effort to obtain information on this subject, the investigators of the cooperative U.S. Department of Agriculture — Virginia Agricultural Experiment Station forage-drying project conducted a study of the change in the chemical analysis of hay during drying. This study was made during two consecutive seasons, and a chemical analysis was made on 96 samples of hay, before drying and after drying, in each of the two years. These samples were obtained from hay being dried under a number of operating conditions. The analysis was made to determine the chemical change of the hay during drying.

Experimental Equipment and Procedure. In each of the two years, eight drying tests were made. Twelve containers were used to hold the hay during each drying test. These containers were 2 ft square and were adjustable in depth from 1½ to 2 ft. This adjustment was accomplished by a telescopic interlining, and the containers were so constructed that when one container was stacked on another, the top of the hay in the bottom container maintained contact with the bottom of the hay in the container just above it (Fig. 1). This contact was desirable to prevent air spaces between the layers of hay. The bottom of each container was made of wire mesh.

The containers were arranged in four columns of three layers each for each of the drying tests, and an airtight gasket of sponge rubber filled the joint between the hay containers. A blower, driven by an electric motor, supplied air to a plenum chamber under each of these columns at the rate of 15 cfm per sq ft of column cross-sectional area. Necessary heaters and regulators were used to maintain the air entering each column at the desired temperature.

Sampling. Eight drying tests were made during each season. All twelve containers were filled for each test with approximately the same weight of alfalfa hay. The initial moisture content of the hay, when loading in the drier, was approximately the same for any one drying test and varied from 34 to 72 per cent (wet basis) for the two seasons. The hay was chopped as the containers were filled and a sample was taken from each during this filling. During the first series of tests, this sample was taken manually before and after drying by removing a small handful at intervals during the loading and unloading. These handfuls were mixed thoroughly and a sample obtained for chemical analysis by quartering. For the second series of tests, the samples were taken before drying by a mechanical sampler(1)* (Fig. 2), which at intervals removed a small amount of hay from the chopper which was quartered for the samples used for chemical analysis. After drying, a core sampler was used to cut the sample from the hay in the different layers in the container.

Procedure. During the first series of tests, each column of three containers was dried with air of different temperatures entering the bottom of the column. The temperatures used were thermostatically controlled at 100, 110, 120, and 130 F. During the drying period, the loss of weight in each container was observed. Weighing each section was accomplished by raising the middle and top section and weighing the bottom; the middle section was lowered and the weight of the middle and bottom determined. Finally, the entire column was weighed. The weight of hay in each section was then determined by subtraction.

In the second series of tests, the experimental procedure

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AUTHORS' NOTE: The authors wish to acknowledge the help of Prof. M. E. Terry, associate statistician, and members of the statistics department, Virginia Agricultural Experiment Station, who conducted the statistical analysis for this work.

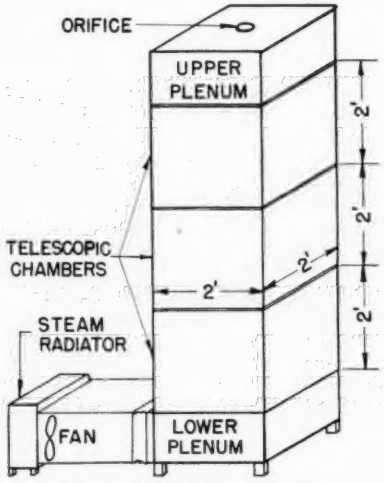

Fig. 1 Sketch of one drying column with telescopic chambers and drying equipment used for both series of tests

*Numbers in parentheses refer to the appended references.

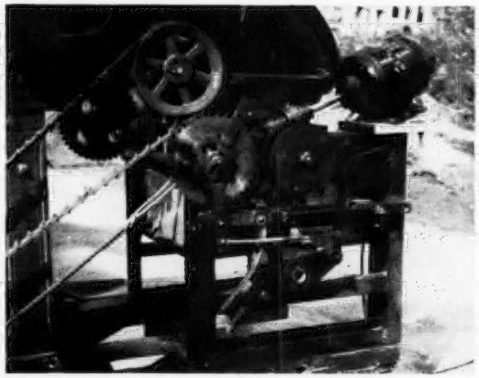

Fig. 2 Mechanical sampler attached to hay chopper. The mechanism shown operates a dividing blade which at regular intervals removes predetermined samples from the hay that is passing through the chopper. The small portion removed from the bulk of the material is deposited in a container under the sampler

Table 1 Summary of Operating Conditions and Statistical Analysis

TESTS	SAMPLING	DRYING TEMP °F	NUMBER TESTS	SAMPLES ANALYZED	STATISTICAL ANALYSIS	SOURCES of VARIATION	PROTEIN	FAT	FIBER	ASH	DRY MATTER
first series 15cfm/ sq ft	by hand	100 110 120 130	8	48	analysis of variance on totals	wet and dry	*	*	*	NS	*
						layers	NS	NS	*	*	NS
						temp	NS	NS	NS	NS	NS
						drying time	NS	NS	NS	NS	NS
second series 15cfm/ sq ft	mechanical	10 20 30 above ambient	8	48	analysis of variance on totals	wet and dry	NS	NS	NA	NA	NS
						layers	*	*	NA	NA	*
						temp	NS	NS	NA	NA	NS
						drying time	NS	NS	NA	NA	NS
					regression coefficients second tests	drying time	0.002	0.0009	NA	NA	0.01
							NS	NS			NS
					regression coefficients both tests combined	drying time	0.002	-.00002	0.005	0.0007	0.02
							NS	NS	*	NS	*

* — significant
NS— not significant
NA— not analyzed for fiber and ash

NOTE: Drying time for first tests varied between 6 and 120 hr, and initial moisture content varied from 35 to 65 per cent (wet basis). Drying time for second tests varied between 8 and 235 hr, and initial moisture content varied from 34 to 72 per cent (wet basis). Variations in moisture was between hay of different tests, not of hay of the same test

differed from that used in the first series in that the temperature of the air used in drying each column was controlled differently. In the first tests, the temperature of the air entering the several columns was thermostatically controlled; in the second tests, the air temperature was allowed to vary with outside temperature with a constant amount of heat added. No heat was added to the air entering one of the four columns. The air entering the other three columns was heated at 10, 20, and 30 F above the outside temperature at all times. This condition is similar to that which would be obtained with a supplementary heat-drying unit burning a constant amount of fuel at all times.

For the first series of tests, the chemical analysis consisted of determining the percentage of protein, fat, fiber, and ash. In addition to these, the amount of dry matter before and after drying was determined. For the second series of tests, only the protein and the fat analyses were made in addition to the dry matter determinations.

RESULTS AND DISCUSSION

First Series of Tests. The chemical data were analyzed statistically for analysis of variance. This is a statistical technique for testing whether several "means" or averages are different. From the results of this statistical analysis (Table 1), it was noted that there was a high degree of significance between the eight replications. This should be expected since hay of varying stages of maturity, fertilization, and cuttings were used in these tests. Extending these tests over an entire season made is impossible to obtain an absolute uniform

TABLE 2. AVERAGE PERCENTAGE OF NUTRIENTS PRESENT BEFORE AND AFTER DRYING FOR THE FIRST EIGHT TESTS
(Sampling by Hand)

	Dry matter, lbs	Protein, per cent	Fat, per cent	Fiber, per cent	NFE, per cent	Ash, per cent
Wet	30.80	18.90	2.60	24.19	46.79	7.50
Dry	30.00	18.68	2.48	25.27	45.92	7.64
Change	−0.80	−0.22	−0.12	+1.08	−0.87	+0.14

material for each of the several tests. The analysis (Table 1) showed that the difference between the chemical analysis of the wet and dry material was significant for fat, fiber, and ash and slightly significant for dry matter and protein. There was no significant difference between the samples from the different temperatures used in the first series of tests. Drying time varied between 6 and 120 hr and initial moisture content varied between 35 and 65 per cent.

TABLE 3. AVERAGE TOTAL AMOUNTS OF NUTRIENTS BEFORE AND AFTER DRYING FOR FIRST TESTS

	Dry matter lb	Protein, lb	Fat, lb	Fiber, lb	NFE, lb	Ash, lb
Wet	30.80	5.82	0.80	7.45	14.41	2.31
Dry	30.00	5.60	0.74	7.58	13.78	2.29
Difference, lb	−0.80	−0.22	−0.06	+0.13	−0.63	−0.02
Per cent of original	−2.6	−3.8	−7.5	+1.7	−4.37	−0.9

Dry matter loss shows that 2.6 per cent of the original dry matter was lost during drying; cause: continued respiration, oxidation, and bacterial action.

After discussion with chemist and plant physiologist, it is believed that the amount of crude fiber would not increase. It is further felt that this apparent increase is due to loss of leaves during sampling. Had there been no loss of leaves during sampling, the percentage of crude fiber in the sample taken after drying would be increased at the rate of dry matter loss or from 24.19 to 24.83 per cent.

Since the greater portion of fiber is in the stems, a loss of leaves would give an increase in the percentage of fiber with respect to the other parts of the plant. Since fiber and ash are very stable, it would not be expected that the amounts of these materials would change appreciably during the drying process; thus a decrease in the dry matter present would be accompanied by an increase in the per cent of these two elements of the chemical analysis. In the case of protein and fat, however, these nutrients showed a decrease which is greater than is indicated by the change in dry matter.

From the dry-matter determinations and the chemical composition of all 48 samples, the total amount of the several nutrients were calculated. The change in the total amounts of each of these nutrients present, before and after drying, was analyzed for variance. This analysis showed the change in total protein and total fat to be highly significant, but the change in total fiber and total ash was not significant. The average weight of protein in each container decreased from 5.73 to 5.49 lb. The total amount of fat present before and after drying decreased from 0.797 to 0.740 lb and the change was highly significant. The change in total fiber and total ash was not significant.

The difference between the total amounts of protein, fat, fiber, ash, and dry matter was plotted against drying time. The drying time in this case was the time in hours required for the hay in each container to reach its 20 per cent moisture content, wet basis, weight. This time varied between 6 and 120 hr for the first tests (Table 1). From these data, the regression coefficient for the loss of each of the nutrients enumerated above and drying time was determined.

The regression analysis is a statistical technique for estimating, experimentally the relationships between several factors; that is,

$$\text{Yield} = X\,1\ \text{Rainfall} + X\,2\ \text{Amt. fertilizer} + X\,3\ \text{Type of seed} + \ldots\ldots$$

$$\text{or Protein} = X\ \text{Temp.} + X\ \text{Layer} + X\ \text{Drying time} + \ldots\ldots$$

These values, however, are not significant due to the random errors encountered in this work.

Second series of tests (Mechanical sampling). For the second season when mechanical sampling was used, one column with natural air and temperature rises of 10, 20, and 30 F were used. The chemical analysis included the determinations of protein, fats, and dry matter. The statistical analysis of these data consisted of an analysis of variance for differences caused by various factors on the change in dry matter, total protein, and total fat (Table 1). Drying time varied between 8 and 235 hr; initial moisture content varied between 34 and 72 per cent. Variation in moisture content was between tests, not between hay of same test. This analysis showed that there was no significant difference between the total amount of dry matter, protein and fat present before and after drying. The significance shown for the different layers in each of these three items is caused by the fact that there was no control over the exact amount of each of the several elements placed in each container. To obtain the effect of layer and temperature, one must go to the interaction between the total amount of these elements present when wet and when dry, times layers or temperature as the case may be. This analysis showed that neither layer nor temperature made a significant difference in the change.

The statistical analysis was conducted and regression coefficients determined for the loss in the total dry matter, protein, and fat against drying time (Table 1). Here again

TABLE 4. AVERAGE PERCENTAGE OF NUTRIENTS PRESENT BEFORE AND AFTER DRYING FOR SECOND TESTS

	Dry matter, lb.	Per cent protein, lb	Per cent fat
Wet	32.79	18.12	3.41
Dry	31.92	18.08	3.38
Difference	−0.87	−0.04	−0.03

TABLE 5. AVERAGE TOTAL NUTRIENTS BEFORE AND AFTER DRYING FOR SECOND TESTS

	Dry matter, lb	Protein, lb	Fat, lb
Wet	32.79	5.94	0.79
Dry	31.92	5.77	0.77
Change	−0.87	−0.17	−0.02
Per cent of Orig.	−2.68	−2.86	−2.53

drying time is that time in hours required for each of the several containers to reach 20 per cent moisture content, wet basis. These regression coefficients were: dry matter, 0.0118; protein, 0.00017; fat, 0.00089, and while they might indicate a trend, they were not significant statistically.

Differences for the Two Seasons. It is felt that the reason significant differences were found in the change of total protein, total fat for the first tests was due to the error encountered in sampling by hand. As has been previously mentioned, the sampling was done by hand, stacking handfuls of hay out of the bin as it was being unloaded. This hay was very dry in many cases and as a result of handling, it is feared that some of the leaves were knocked off. Morrison(2) gives the following composition of alfalfa leaves and stems:

	Moisture	Protein	Fat	Fiber	NFE	Ash
Alfalfa leaves, per cent	11.0	21.9	3.0	14.1	39.8	10.2
Alfalfa stems, per cent	11.6	10.0	1.2	36.6	34.2	6.6

When these data are computed to a 0 per cent moisture, they become:

	Protein	Fat	Fiber	NFE	Ash
Alfalfa leaves, per cent	24.6	3.37	15.8	44.72	11.46
Alfalfa stems, per cent	11.29	1.35	41.31	38.60	7.45

According to the official U.S. hay standards, the No. 1 grade of alfalfa requires 40 per cent of the plant to be leaf and 60 per cent stem. Thus the total amounts of the several elements in 40 lb of leaves and 60 lb of stems of 100 lb of No. 1 alfalfa hay becomes:

TABLE 6. TOTAL NUTRIENTS IN 100 LB OF U.S. NO. 1 ALFALFA HAY

	Protein	Fat	Fiber	NFE	Ash
Leaf	9.84	1.35	6.32	17.89	4.58
Stem	6.77	0.81	24.79	23.16	4.47
Total	16.61	2.16	31.11	41.05	9.05
Per cent in leaf	59.2	62.5	20.3	43.6	50.6
Per cent in stem	40.8	37.5	79.7	56.4	49.4

Table 6 shows that the leaf carried a large portion of the protein and fat in the plant. The loss of leaves would mean that the chemist would analyze a sample that was lower than the lot of hay. A study was made of a possible method of adjustment for this loss in protein and fat and the gain in fiber. This adjustment shows that a loss of 5 per cent of the leaves would be sufficient to cause all of the apparent loss in protein and the apparent gain in crude fiber. Thus the loss of leaves indicated in the gain in crude fiber is sufficient to account for the indicated loss in protein and ash, but not for the fat and NFE (nitrogen-free extract). This would indicate that dry matter loss is caused by respiration, for in respiration the carbohydrates and fats are the most readily consumed. Since the greater portion of the fiber is in the stems, a loss of leaves would give an increase in the percentage of fiber with respect to the other parts of the plant.

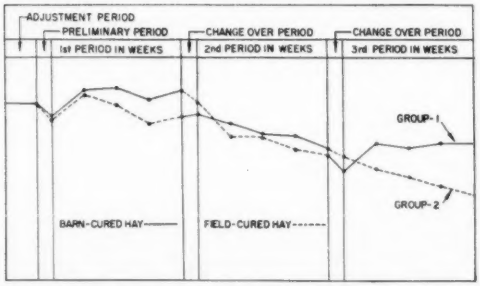

Fig. 3 Milk-production trends of two groups of cows (6 cows in each group) fed barn-cured and field-cured alfalfa hay

Mold Growth in Barn Hay Curing. Mold growth was observed in a number of the samples taken from the small driers. In the first series of tests, the mold appeared much more frequently and quicker than in the second series of tests. It is felt that this is due to the fact that, in the second tests, the condition of the air used for drying was varying continually from a maximum to a minimum and back to maximum as the outside temperature varied, while in the first tests the air was thermostatically controlled and held constant. The variable conditions meant that the temperature in the hay was varying constantly and if an optimum condition for mold growth was obtained it did not persist for any length of time.

COMPARISON OF FIELD-CURED AND BARN-CURED HAY

In other trials(3) at this station, hay from the same cutting from the same field was divided by alternate windrows. One half was cured with a barn drier using atmospheric air and the other half was cured in the field. This hay was cut at the recommended stage of maturity. The hay for the barn drier was allowed to wilt in the field until the moisture content was about 45 per cent wet basis. Then it was placed on the drier loose. Comparisons of the two hays were made on (a) chemical analysis, (b) carotene content, (c) digestibility, (d) effect on milk production, and (e) effect on weight of the cows. These trials compared hay cured by these two methods on the basis of pound for pound of the finished hay. No account was taken of the losses during curing.

The barn-cured hay was considerably higher in protein, containing 20.2 per cent compared to 17.6 per cent for the field-cured hay. Ether extract was slightly higher in the barn-cured hay. On the other hand, the field-cured hay was higher in crude fiber and in nitrogen-free extract. The higher content of protein and the lower content of crude fiber in the barn-cured hay could, in all probability, be attributed to a greater retention of leaves.

Carotene content was determined on twenty samples of each kind of hay. The average carotene content of the barn-cured hay was 34.8 micrograms per gram compared with an average of 19.6 micrograms for the field-cured hay. This represents approximately 75 per cent more carotene in the barn-cured hay. However, these figures are both low. The samples were taken from the barn in February which allowed for several months of carotene destruction in both types of hay.

Digestibility trials were run to compare the digestibility of the nutrients in the two kinds of hay. Protein in the barn-cured hay was 74.3 per cent digestible and 70.8 per cent in the field-cured hay. The digestibility of the ether extract was low in both hays, being higher in the field-cured hay, 24.9 per cent compared with only 17.8 per cent in the barn-cured hay. There were no significant differences in the coefficients of digestion of the other nutrients in the hay.

In milk production trials, using the double-reversal method, the group on barn-cured hay produced slightly more milk in every period (Fig. 3). While the differences were not great, they were significant. The average difference in the changes in live weight of the cows on the two kinds of hay was not significant.

SUMMARY AND CONCLUSIONS

1 The over-all trend, under the conditions of these tests, shows that there may be losses of protein, fat, fiber, ash and dry matter during drying and these *(Continued on page 223)*

Grounding of Electrical Farm Equipment

By N. E. Macpherson
MEMBER A.S.A.E.

THIS paper is based on an 8-year investigation of the grounding of farm services by the research panel on grounding of The Hydro-Electric Power Commission of Ontario. The distribution system is of the multigrounded, primary-neutral type with primary and secondary neutrals interconnected at the transformer, with a relatively small mileage of ungrounded delta connected or ungrounded lines without primary neutral.

Prior to 1932 the secondary service neutral was grounded at the transformer only and the metal enclosures of the wiring system and equipment were connected to driven rods. In 1932 the regulations were changed, requiring the grounding of the secondary circuit neutral at the transformer and at the main service entrance. This resulted in all equipment enclosures bonded to the ground rod at the main service entrance equipment being also bonded to the neutral. In 1947 the regulations were again changed, requiring the bonding of the metal enclosures of the wiring system and equipment to the neutral conductor in the feeder entrance equipment at that building and also to a driven rod and required the bonding of the water system to this ground and neutral conductor at the entrance to each building the water system served.

The factors contributing to equipment or wiring system failures are the accelerated deterioration of wiring and equipment due to the presence of condensation and corrosive fumes existing in many stables, milkhouses, etc. Failure to maintain equipment in proper condition, mechanical abuse, and the use of unapproved wiring materials are also contributing factors. The exposure of farm wiring systems and rural lines to lightning has been found to be a major contributing factor.

The hazards from ground faults due to failure of the insulation of equipment arises from the widespread use of metal stanchions in contact with piping systems which in turn are in contact with the electrical equipment such as milking machines, water pumps, electric water heaters, and soil-heating cable for frost protection, etc. This situation results in the cattle being in contact for long periods with structures which may become energized by failure of the insulation in electrical equipment.

Cattle are known to be very sensitive to electric shock and while the limits have not been too definitely established, evidence during the course of this study indicated that sustained voltages of 10 to 15 v will prevent cattle from drinking, sustained voltages of 15 to 30 v subject cattle to mild shocks, and sustained voltages of 30 to 50 v should be considered hazardous and possibly fatal to cattle under severe exposure. It is, however, generally accepted that substantially higher voltages, if of short duration, can be endured and do not present a serious hazard.

The effects of ground faults are apparent in the reports of electrocution of cattle, and while these cases are fortunately relatively rare, they represent a serious financial loss to the individual and usually receive wide publicity. A much larger number result in excessive consumption or reports of shocks received by persons or animals from equipment which normally should not be "alive" and causes inconvenience and expense to the consumer. Of all such cases investigated during the course of this study, approximately 94 per cent have been due to sustained potentials from ground faults in the wiring or equipment, and it is apparent that a large number of cases are detected and repaired without being reported. The wiring system therefore must not only be adequate with respect to its capacity, but should also incorporate the maximum degree of self-protection that can economically be obtained.

Purpose of Grounding. The necessity of grounding has long been recognized by the electrical codes which provide a minimum standard of good practice. These codes recognize two separate grounding requirements, as follows:

1 The grounding of metal enclosures of wiring systems and equipment with which contact may be made, in order to maintain such equipment at earth potential and to reduce the potentials which otherwise would appear on the enclosure under fault conditions.

2 The neutral conductor of the secondary circuit is required to be grounded in order to limit the maximum normal potential of the circuit with respect to ground and to reduce the potentials which could occur due to lightning or primary faults.

There are therefor three sources of potential to be guarded against, each having its own requirements, namely, secondary potentials, primary potentials, and lightning. In urban or suburban areas, extensive metallic public water systems provide an ideal low-resistance ground electrode. Farms, however, are almost invariably limited to the use of driven pipe or rod electrodes whose resistance varies over wide limits, and in many areas it is impractical to obtain reasonable low-resistance values due to high soil resistivity or the presence of sand, gravel, or rock.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1950, as a contribution of the Power and Machinery Division.

The author: N. E. MACPHERSON, assistant rural service engineer, The Hydro-Electric Power Commission of Ontario, Canada.

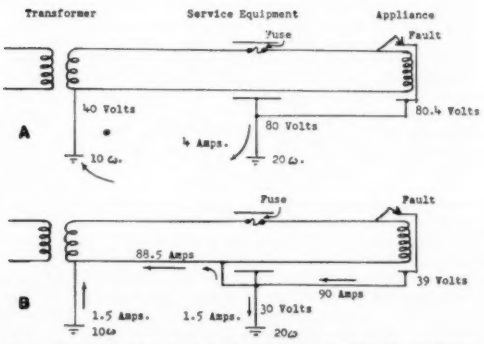

Fig. 1 Secondary fault: A, isolated equipment grounds; B, equipment ground bonded to secondary neutral

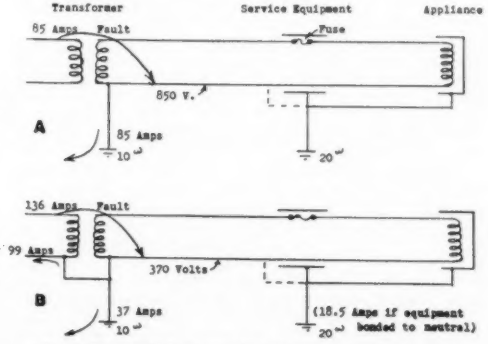

Fig. 2 Primary fault to secondary neutral: A, neutrals isolated; B, primary and secondary neutrals

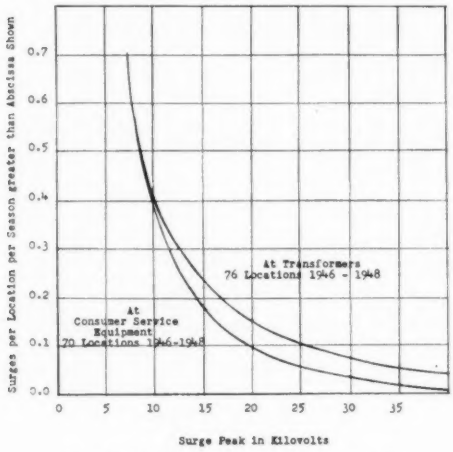

Fig. 3 Klydonograph recording of surge potentials

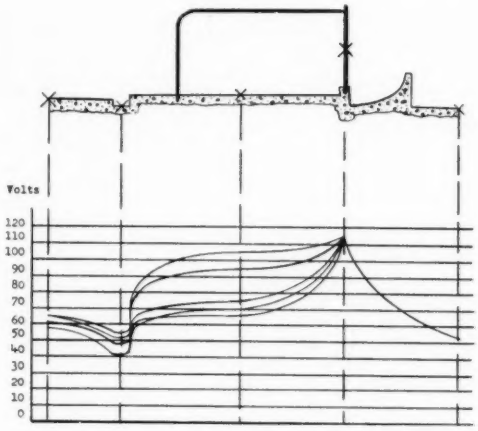

Fig. 4 Illustrating the effect of the gutter and the variation in individual stalls. Potential gradient from metal stanchions to floor on center line of five stalls, with 115 v applied to stanchions having a resistance of 7 ohms to ground

Secondary potentials. The protection afforded by grounding in the case of secondary faults is illustrated in Fig. 1 which is a simplified schematic diagram of the essential parts of a farm service. It will be noted that the fault current path is from the metal enclosure of the faulty equipment to the equipment ground electrode through earth and returns to the neutral of the circuit through the circuit ground electrode. The resistance of these two ground electrodes are in series and due to the fault current, voltage drops occur at each electrode. These voltages appear on the metal enclosures of equipment bonded to them and also as a potential gradient in the earth adjacent to the electrodes.

The portion of line to neutral voltage which will appear on the enclosure of the equipment is dependent on the ratio only of the resistance of the equipment ground to the total resistance of the fault circuit and not on the value of the resistances.

The fault current, however, depends on the total resistance only. In order that a 15-amp branch circuit fuse may function under a fault, the total resistance of the circuit must be less than 8 ohms. To ensure that such a fuse will operate in less than 2 sec, 30-amp fault current will be required or a circuit resistance of 4 ohms or less. To obtain such low values of fault circuit resistance is obviously impractical by means of driven ground electrodes, and as a result the branch circuit protective devices offer little or no protection from ground faults, resulting in sustained hazardous potentials on equipment and potential gradients in the earth.

Ground faults may be due to metal contact between energized conductors and the frame of equipment or they may be due to insulation puncture as a result of lightning which may initiate a power arc. It is a well-known fact that a resistance in series with an arc stabilizes the arc, which will continue to burn until metal-to-metal contact is established. Such sustained arcing grounds present a real fire hazard.

Since fault currents must return to the neutral, the alternative of bonding metal enclosures directly to the neutral is apparent. This is illustrated in Fig. 1(B) which shows the enclosure of equipment bonded by a separate grounding conductor to the feeder entrance equipment where it is bonded to the neutral and the ground electrode. Such an arrangement provides a low-resistance metallic path for the fault current which short-circuits the ground electrode resistances. This results in large fault currents, ample to operate branch circuit protective equipment promptly, thus clearing the fault. The potentials appearing on equipment enclosures are limited to the resistance drop in the return path and are of momentary duration. No hazardous potential gradients exist at the ground electrodes and arcing grounds are suppressed.

Primary Potentials. Primary potentials may be applied to secondary wiring systems through accidental contact with a primary conductor, or due to breakdown of the transformer insulation, usually initiated by lightning. Such potentials present real shock and fire hazards due to breakdown of secondary insulation. Grounding the secondary circuit neutral will reduce these potentials, but as this ground resistance is in series with the fault current path it reduces the fault current and may delay the operation of the primary fuse. Just as in the case of secondary faults a greater degree of protection is afforded by bonding the primary and secondary neutrals together thus permitting a maximum fault current which will operate the fuse in the shortest time.

This interconnection has a further advantage in that it reduces the electrical stress between windings during lightning surges, and operating experience has demonstrated that it substantially reduces transformer winding failures and flashovers and thus the danger of involving the secondary circuit. This interconnection together with the improved characteristics of modern transformers has resulted in primary faults being of rare occurrence.

Lightning Potentials. Lightning-stroke potentials are of very high magnitude and short duration (milliseconds). The energy content and damage done varies through wide limits. Due to the steep wave front of such discharges, high potential drops occur along the discharge path which result in flashovers to adjacent grounded metal structures. When we consider the extent of grounded metal structures in farm homes and barns, such as water pipes, drainpipes, heating systems, stanchions, litter carriers, structural parts of buildings and the wiring system, the possibility of flashover and the difficulty of maintaining adequate separation is apparent. Under such conditions, bonding of metal structures together reduces the potential difference between them and offers the maximum protection against lightning flashover and the hazards of fire and damage to electrical equipment.

Primary Neutral Potentials. The bonding of the primary and secondary neutrals to provide protection against ground faults to the secondary wiring system obviously subjects the secondary neutral and all equipment bonded to it to any potentials appearing on the primary neutral. All grounded metallic structures bonded to the secondary neutral are in parallel with the grounds of the primary neutral and will share with them in the interchange of current between pri-

mary neutral and ground. Such potentials may be due to (a) sustained voltages due to primary neutral load current, (b) voltages due to primary fault currents, and (c) lightning surges.

In order to investigate the degree of hazard involved from this interconnection with the primary neutral, the electrical research department of the Commission made a survey of neutral potentials in a large section of farming country in southern Ontario. Seventy-six rural lines were investigated and graphic records kept of the neutral potential, obtained at twenty locations where the largest neutral potentials could be expected, for periods of two weeks. Of the 76 lines investigated, 72 had potentials of 5 v or less, and one had 7 v. At the end of one line, a maximum of 17 v was reported. In two other cases adjacent to distributing stations, 19 v was reported at one location, and 16 v at another.

In summer-resort areas where difficult grounding conditions exist due to sand, gravel, and rock, neutral potentials were investigated at 41 locations, nine of which had potentials in excess of 10 v, and three of these were from 25 to 28 v. Additional grounding with long rods at selected locations has proved effective in reducing these voltages particularly in the farming areas. This survey has indicated that sustained voltages on primary neutrals due to load current do not normally present a serious hazard and where they do occur, can be reduced by additional grounding.

An investigation of the voltages resulting from phase to neutral primary short circuits was made on a farm line. This line consisted of 1½ miles of 3-phase and 4½ miles of single-phase. A short circuit applied to the end of this line protected by a 15-amp fuse resulted in voltages of 370 volts for 0.8 sec duration. With 15 extra consumers' service grounds connected as they would be under modern construction, 204 v were obtained at the point of fault.

A short applied 1.7 miles from the end of the line with no extra consumer grounds connected produced 220 v at the point of application and 135 v at the end of the line, for a duration of 0.4 sec.

To determine the effect of an open neutral, the neutral conductor was opened at a point 1.7 miles from the end of the line and a short circuit applied at the end of the line. A voltage of 445 v was measured without extra consumer grounds and 225 v when such consumer grounds were connected.

The development of a simplified klydonograph recording unit in the Commission's laboratories has greatly facilitated the study of surge potentials. Seventy-six klydonograph installations were made from the neutral to a separate ground connection at the distribution transformer and 70 installations between neutral and ground at consumers' service entrance equipment and records obtained for three lightning seasons. The results indicate that 38 per cent of the consumers will receive a surge of about 10,000 volts each year, 15 per cent about 20,000 volts, 6 per cent about 30,000. While these lightning surges are of relatively high voltage and of frequent occurrence they are undoubtedly dissipated by the grounding on the customers' premises and may result in flashover from neutral terminals to grounded metal enclosures. As the neutral is not energized, they do not establish power arcs. The Commission's system has operated with this interconnection since the early 'twenties with these surges on the neutral, and no evidence has been established that they present a hazard.

CONCLUSION

This study has led to the conclusion that practically complete protection could be obtained for ground faults on the customer's own equipment by bonding all metal enclosures and structures, in contact therewith, to the secondary neutral. This could include metal stanchions without hazard to the livestock since the ground forms no essential part of the fault current path in these cases.

This method permits the branch circuit fuse to operate promptly clearing the fault and prevents the hazard of arcing grounds. The fact that approximately 86 per cent of the fatalities to dairy cattle have been due to secondary equipment failure makes the adoption of this system of protection very attractive.

Its adoption, however, is limited due to the fact that it increases the exposure of cattle in stanchions to substantial voltages of short duration due to primary faults, particularly where the primary and secondary neutrals are interconnected. The extent of such increase is not too well known and would depend on the conductivity of the primary neutral and the effectiveness of its grounding. Offsetting this is the fact that bonding all secondary grounds to the primary neutral reduces its resistance to ground and substantially reduces the magnitude of primary fault voltages. This undoubtedly provides protection from fire hazard due to arcing grounds, which may otherwise occur with primary faults.

The ratio of fatalities due to primary faults as compared to secondary faults during this study has been 1 to 15, indicating the extent of improvement possible.

Where it is not desirable to increase the exposure of cattle, consideration could be given to the following:

1 Separation of primary and secondary neutrals, with the sacrifice of the protection afforded by such connection.

2 Isolation of the stanchions from contact with all grounded metal structures, by insertion of insulating links in the water and milker pipe lines.

3 Some means of reducing to safe values the potential gradients between stanchions and gutter or other parts of the floor, such as a grounded metallic grid in or beneath the floor slab effectively bonded to the stanchions. This could be considered only in new construction but would be of merit regardless of the method of grounding.

Composition of Hay in Barn Drying

(Continued from page 220)

losses may increase with drying time; however, the losses obtained due to drying were not enough to be statistically significant when analyzed separately for the two series of tests.

2 When both series of tests were combined, the regression coefficients for the losses for protein, fat, and ash taken separately, were not significant statistically when drying time varied from a minimum of 8 hr to a maximum of 235 hr. When the losses of protein, fat, and ash were combined in dry matter, the multiple regression coefficient was significant statistically. The regression coefficient for the loss in fiber with drying time was significant statistically. This analysis shows that an increase in drying time will cause an increase in the losses of dry matter and fiber.

3 The temperature at which the hay was dried was not in itself a factor. It was a factor only in so far as it affected drying time.

4 It was found that a loss of 5 per cent of leaves with alfalfa hay during sampling may account for most of the apparent losses during drying.

5 Mold growth for a drying temperature that varied from a maximum to a minimum during drying was not as great as when the temperature was thermostatically controlled and held constant.

6 In trials with field-cured and barn-cured hay (no supplemental heat), the protein was higher in the barn-cured hay and had a higher digestive coefficient.

7 The barn-cured hay had a higher carotene content.

8 In milk production trials, the barn-cured hay produced slightly more milk in every period of the trial.

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1951 ASAE Annual Meeting Opens Vistas of Interest

Plans for Houston ASAE Meeting

PLANS are progressing rapidly for the 1951 ASAE Annual Meeting at Houston, Texas, June 18 to 20. As host of this meeting, the Southwest Section of ASAE is looking forward to the biggest summer meeting which the Society has ever had. The Southwest is perhaps one of the fastest growing areas in the country both from an agricultural and industrial standpoint, and Houston is recognized as the metropolis of the South and Southwest and has experienced a spectacular growth during the past two decades. It is the center of the oil and gas industry of the Southwest and is also in an area of extensive agricultural production. Houston is likewise one of the leading seaports being connected to the Gulf of Mexico by a 35-mile ship channel. It is but a day's drive to the Lower Rio Grande Valley and Old Mexico, San Antonio, and other historical and interesting places. The University of Texas is located at Austin, the state capitol, only 150 miles from Houston, and A. and M. College of Texas at College Station is just an easy two-hour drive. Galveston on the Gulf offers fine bathing, fishing and pleasure facilities and is just an hour's drive from Houston.

Plans are being made for entertainment and sightseeing tours for everyone attending the ASAE meeting, insofar as they will fit into the program. Those ASAE members who haven't seen the Southwest, this is their opportunity. The principal objective of the local sponsoring group is to make this meeting interesting, instructive, and enjoyable to everyone. Further information concerning housing, travel, entertainment and the like will be published in AGRICULTURAL ENGINEERING or mailed out to members in due time.

Louisiana Extends Welcome to ASAE Members

ASAE MEMBERS from the East and Southeast, normally, will drive through Louisiana on their way to Houston to attend the 1951 annual meeting. Members from the upper Mississippi valley will find it to their interest, with little or no increase of mileage, to see certain sections of the state. Those who may cross Louisiana twice, coming to the meeting and returning home, might well select two different routes in order to see more of the state.

The director of the Department of Highways, Baton Rouge, advises that his office will be happy to furnish highway maps of Louisiana to all who will write for them. The Department of Commerce and Industry, State Capitol, Baton Rouge, likewise, will welcome the opportunity to mail booklets and pictorial leaflets describing features of special interest to tourists.

The agricultural engineering department at Louisiana State University, Baton Rouge, will be waiting expectantly for visitors before and after the annual meeting. We'll be happy to take you through our new building.

The two cities that hold perhaps the greatest interest to the tourist are Baton Rouge, with its capitol (the tallest in the U.S.), the L. S. U. campus and the large industrial plants of Esso Standard Oil, Ethyl Corporation, Solvay and others, and New Orleans, that city with its famous French cuisine and old-world charm. (By the way, the Louisiana pronunciation of New Orleans is "New *Or*-lins", *not* "New Or-*leens*"; in fact, it is something that sounds as though spelled "N'*ah*-lins").

There are areas in the state, also, which are peculiar to Louisiana. One of these is the strawberry and trucking region near Hammond (50 miles east of Baton Rouge, and 55 miles north of New Orleans). Another, the Evangeline Country, home of the Acadians, is in and around St. Martinville (64 miles northwest of New Orleans, U.S. 90 and La. 25; 89 miles west and south of Baton Rouge on U.S. 190 and 167). The sugar cane area — Louisiana's Sugar Bowl—lies between New Orleans and Baton Rouge, and also between New Orleans and Lafayette, extending on to Opelousas through the Teche Country (pronounced "Tesh"; rhymes with fresh) on U.S. 90 and 167. The rice-growing area is found mainly between Lafayette and Lake Charles, in the southwestern part of the state, on U.S. 90.

Near New Iberia (on U.S. 90 between New Orleans and Lafayette) is Avery Island, where one finds the Jungle Gardens, a bird sanctuary, and several salt mines. Below New Orleans are sulphur mines and citrus groves. Throughout the southern and northern areas of the state are numerous oil and gas wells.

Those who have not seen "N'*ah*-lins" will have an excellent opportunity at this season. This city, famous in song and story, will be of great interest. It is the home of Tulane and Loyola universities, Newcomb college for women, and the L. S. U. Medical School. The southern U.S. Regional Laboratory is in New Orleans. Another institution, of a sort not found elsewhere, is the International Trade Mart, something distinctly and uniquely different. Then, there's the Old French Quarter (the Vieux Carre) with its narrow streets, "galleries" of iron lacework, quaint shops, and famous restaurants; there's the old French Market; there's the Father of Waters, the Mississippi, and the possibility of a steamer excursion; the old St. Louis Cathedral, and the nearby prison cell of Jean Lafitte, the pirate of ancient days.

Come to Louisiana; we welcome you most cordially. — E. B. (Ed) Doran, head, agricultural engineering dept., Louisiana State University.

Attractions for Agricultural Engineers in Arkansas

AGRICULTURAL engineers who pass through Arkansas on their way to the 1951 ASAE annual meeting at Houston, Tex., in June will find much of interest along the way. Those entering the state from the east will find themselves in the Delta country, where most of Arkansas' cotton production is now concentrated. In the northeastern corner are the large plantations where the shift to mechanical production is furthest advanced.

Farther west along the road toward Little Rock one enters the "Grand Prairie" rice area. Rice production has spread to the northeastern and southeastern boundaries of the state, but the Grand Prairie is the oldest and most concentrated rice growing area. Twenty miles south, on U.S. 11, is Stuttgart, the rice capitol. Here are several rice mills, including the largest in the state. Here also is the Rice Branch Experiment Station.

The state has a number of mineral springs and caves. Southwest of Little Rock is Hot Springs, the site of the Hot Springs National Park. Near the northern border of the state is Eureka Springs, the "Little Switzerland" of Arkansas, which has been compared to an Alpine village. Mammoth Spring is also on the Arkansas-Missouri border, but further east, and between the two is Norfolk Lake, a fisherman's paradise, created by the Norfolk dam on the White River. Another, even larger dam, Bull Shoals, is under construction further up the White River.

In the northwestern part of the state is the scenic Ozark Mountain country, which attracts thousands of visitors from all over the country

This is the downtown area of Houston, Tex. The E-shaped building above and to the right of center is the Rice Hotel — 1951 ASAE annual meeting headquarters

This picture shows the San Jacinto Battleground with the San Jacinto Monument, the battleship Texas and San Jacinto Inn, all of which are located on the ship canal about 25 miles from Houston, Tex.

each year. In the Ozark National Forest, and the Ouachita National Forest to the south, are many recreational areas and state parks, some with overnight accommodations.

Fayetteville, the home of the University of Arkansas and the main state agricultural experiment station, is on U.S. 71 in western Arkansas. The national finals of the chicken-of-tomorrow contest (held every three years) are now going on at the University. A large celebration is being planned for the week of June 11 to 16, with parade, pageant, chicken barbecue, and on June 16 the announcement of winners. Visitors are invited to inspect the two large broiler houses built for the contest and the prize birds entered by 40 contestants from all parts of the country. During the final days' events, live and dressed specimens of each contestant's entry will be on display.

Awards for Slide Display

THE ASAE Committee on Extension is sponsoring, among other exhibits, a 2x2 slide display and exchange in connection with the Society's annual meeting at Houston, Texas, June 18 to 20. Ribbon awards will be given for the three best educational slide sets or film strips. The purpose of this activity is to provide for greater distribution of visual-aid material.

Following will be the basis for judging the slide sets or film strips submitted in competition for the awards: (1) subject matter, 35 points; (2) effective presentation of ideas, 30 points; (3) quality of pictures, 20 points; and (4) organization and arrangement, 15 points.

The subcommittee in charge of this project has established the following entry rules:

1 Submit 2x2 slide sets or 35-mm film strips (black and white or kodachrome). Awards will be given only for sets consisting of 10 or more slides, preferably not more than 30.

2 Number each slide in consecutive order and include a complete description of each slide in the set.

3 Subject material must be for educational use only. Commercial or selling presentations should not be submitted.

4 To be eligible for awards, descriptions of slide set or film strip must be submitted before June 1, 1951, to G. O. Schwab, agricultural engineering dept., Iowa State College, Ames, and indicate whether or not duplicate sets will be available and the approximate cost. (Slides or film strips may be mailed to Mr. Schwab prior to June 1, or turned in at the ASAE registration desk at Rice Hotel, Houston, Tex., before noon on June 18. All material will be returned to the senders.)

Press and Radio Release Exhibits

EXHIBITS of press and radio releases, in the annual competition and display sponsored by the ASAE Committee on Extension, will be extended this year to include exhibits from commercial and trade groups as well as from public service extension agencies.

Dale O. Hull, extension agricultural engineer, Iowa State College, is handling this section of the exhibits. He suggests that persons interested in providing entries of this type of extension activity contact him in the near future for further details. He should be addressed at Room 201, Agricultural Engineering Building, Iowa State College, Ames, Iowa.

In general the material wanted for exhibits in this section includes releases announcing significant new techniques, processes, or machines, research developments, and public relations. Releases covering contributions of the organization or individual employees to the defense program are to be included. Magazine articles prepared by employees will also be handled in this section of exhibits. Samples of advertising folders are not desired. Each exhibitor will be asked to combine all material for submission in one bound volume with a cover of suitable design. Entries are to be in the hands of Mr. Hull by June 10.

1951 ASAE Safety Award

THE Committee on Farm Safety of the American Society of Agricultural Engineers is sponsoring the second annual ASAE Safety Award, the purpose of which is to encourage extension agricultural engineers in promoting farm and home safety by the use of demonstration and exhibit material or by cooperating with other agencies.

The National Association of Mutual Insurance Companies is encouraging this activity by presenting suitable recognition to the individual winner and to the agricultural engineering department or extension service of the state agricultural college by which the winner is employed. It is hoped that these citations for outstanding achievement in the field of safety will encourage others to take an active interest in the program of saving farm lives and property.

The competition will be divided into three separate divisions for judging, as follows:

Class 1. Demonstration aids together with necessary instructions for presenting and educational materials used in conjunction with the visual-aids material on *Farm and Home FIRE Safety*.

Class 2. Demonstration aids together with necessary instructions for presenting and educational material used in conjunction with the visual aids material on *Farm and Home ACCIDENT Safety*.

Class 3. A report together with supporting material and/or data regarding individual cooperation with other agencies within the extension service, radio stations, insurance companies, civic, farm or commercial organizations, etc., on the subject of *Farm and Home FIRE and ACCIDENT Safety*.

The rules for participation are few and simple, as follows: (1) Competition is open to all extension agricultural engineers or specialists who are members of or are eligible for membership in the American Society of Agricultural Engineers. (2) All exhibits or demonstration material must be planned or built by the contestant making the entry. (Commercial exhibits are not eligible.) (3) Entries under classes 1 and 2 above should be of such material and construction that they can be easily transported in an automobile and readily assembled for use. (4) *All entries must be on display at the 1951 annual meeting of the American Society of Agricultural Engineers at the Rice Hotel, Houston, Tex., June 18-20.*

All entires should be made or additional information obtained by addressing Russell E. Heston, agricultural engineer and safety director, National Association of Mutual Insurance Companies, 2105 N. Meridian St., Indianapolis 7, Ind. All entries must be made a matter of record by May 10, 1951.

Defense Organization

(Continued from page 201)

to defense should be left where they are, if at all possible. Vacancies in defense work should be filled, so far as possible, by men not already engaged in work important to defense.

5 Agricultural engineers are comparatively scarce specialists, generally best qualified to do the agricultural engineering work required for effective defense organization in depth.

6 To the extent that agricultural engineers may be available in addition to those needed to meet defense requirements for agricultural products, they can generally be used to best advantage in engineering and related work dealing with materials, mechanisms, construction, conditions, and other factors similar to those encountered in agricultural engineering.

Some misassignments of agricultural engineers will occur, but with individual and group attention to the problem, they may be held to a minimum.

NEWS SECTION

ASAE Officers for 1951-52

AS the result of the regular annual election of officers of the American Society of Agricultural Engineers conducted by letter ballot of the corporate members of the Society during February and March, the following officers have been elected and will take office at the close of the Society's Annual Meeting to be held in Houston, Tex., June 18 to 20:

President—Stanley M. Madill, executive engineer, John Deere Waterloo Tractor Works of Deere and Company, Waterloo, Iowa.

Vice-President (3-year term)—Edwin L. Hansen, partner, Hansen Brothers Agricultural Engineering Sales and Service, Hillsdale, Ill.

Councilor (3-year term)—Howard Matson, chief, water conservation division (Region 4), Soil Conservation Service, U. S. Department of Agriculture, Fort Worth, Tex.

Nominating Committee—A. W. Farrall (chairman), head, agricultural engineering department, Michigan State College, East Lansing, Mich.; T. E. Hienton, head, division of farm electrification, U. S. Department of Agriculture, Beltsville, Md., and W. W. Weir, drainage engineer, division of soils, University of California, Berkeley, Calif.

The Council of the Society for the year 1951-52 will include the above-named officers together with the following: F. J. Zink and F. C. Fenton, past-presidents; K. W. Anderson, F. A. Kummer, R. C. Hay, and W. D. Hemker, councilors.

Members of the Society are invited to send any member of the Nominating Committee such suggestions as they may have for nominees for the election of officers of the Society in the next annual election of officers which will be held early in 1952. It is desirable that such suggestions reach the Nominating Committee on or before June 1, 1951.

1951 ASAE Annual Meeting Program Features

PLANS for the program of the annual meeting of the American Society of Agricultural Engineers, June 18 to 20, at the Rice Hotel, Houston, Tex., are well advanced. They promise an interesting and profitable three days of attention to new developments and problems emphasized by defense demands on agriculture and its service industries.

Only one general session has been scheduled. It will feature the annual address of the ASAE President, Fred C. Fenton, head of the agricultural engineering department of Kansas State College, and an address by Louis P. Merrill, regional conservator (Region 4), Soil Conservation Service, U. S. Department of Agriculture. He will speak on soil and water conservation problems in the Southwest. This session will be held on Monday afternoon, June 18, and will be followed by the annual business meeting of the Society.

A session on agricultural aviation, of outstanding general interest, sponsored by the Power and Machinery Division, is scheduled for Tuesday afternoon, June 19. E. W. Lehmann, chairman of the Society's Committee on Agricultural Aviation, will preside. Fred E. Weick, of the personal aircraft research center, A. and M. College of Texas, will report on Texas cooperative agricultural aviation research project. This paper will be followed by an address on a research program in agricultural aviation by Dr. K. Starr Chester, agricultural research section, Battelle Memorial Institute.

With this introduction to current developments in agricultural aviation, the balance of the program will be a field demonstration of agricultural aviation equipment.

The College Division program will open Monday evening. Program details have not yet been announced.

Monday evening's schedule also will include a Rural Electric Division program and committee and other special group meetings. One of these of wide interest will be an open meeting sponsored by the Committee on Extension. Exhibits of various types of extension material, separately announced, promise to be larger than ever this year. This is an activity of the Extension Committee.

A Texas-style barbecue on Tuesday evening will bring the whole group together for entertainment and relief from intensive preoccupation with technical and professional features of the program.

Special entertainment for ladies and children will be announced later.

A general session of the College Division will be the main event scheduled for Wednesday afternoon, June 20. The program it will offer has not yet been announced.

High point of each annual meeting is the ASAE Annual Dinner. This has been scheduled as the closing event, Wednesday evening, by way of letting the whole meeting build up to its natural climax.

A.S.A.E. Meetings Calendar

April 20—MINNESOTA SECTION, agricultural engineering bldg., University Farm, St. Paul.

May 5—MICHIGAN SECTION, Toledo Edison Co. Club, Maumee, Ohio

May 5—IOWA-ILLINOIS SECTION, Short Hills Country Club, East Moline, Ill.

May 11 and 12—VIRGINIA SECTION, Patrick Henry Hotel, Roanoke, Va.

June 18-20—ANNUAL MEETING, Rice Hotel, Houston, Tex.

August 27-29—NORTH ATLANTIC SECTION, Chalfonte-Haddon Hall, Atlantic City, N. J.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to A.S.A.E., St. Joseph, Michigan

The forenoons of each of the three days are to be devoted to concurrent sessions of each of the Society's four technical divisions. The programs of these sessions follow:

POWER AND MACHINERY PROGRAM

Mechanization of cotton production will be the central theme for Monday forenoon opening session of the Power and Machinery Division. E. W. Tanquary, chairman of the Division, will preside and offer a program of four papers as follows:

"Results of Studies on Cotton Mechanization in California" by J. R. Tavernetti, University of California, and B. B. Ewing, U. S. Department of Agriculture

"Breeding and Adaptation of Cotton in Relation to Mechanization" by George J. Harrison, U. S. Cotton Field Station, U. S. Department of Agriculture

"Recent Developments in Mechanization of Cotton Harvesting in Texas" by H. F. Miller, A. & M. College of Texas

"Progress in Cotton Harvesting Mechanization in the Southeast" by F. A. Kummer, Alabama Polytechnic Institute.

Attention to cotton will be continued during the first half of the Division's Tuesday forenoon session. "Development of a Brush-Type Cotton Harvester" is to be reported by W. J. Oates, R. H. Wirt, and W. S. Wood of Oklahoma A. and M. College.

C. R. Hagen of International Harvester Co. is to round up this phase of the program with a summary of "Twenty-Five Years' Experience in Cotton Picker Development."

Following an intermission interest will be shifted to other fields with a contribution by Wayne H. Worthington, John Deere Waterloo Tractor Works, on a method of evaluating tractor fuels. This will be followed by a presentation of a paper, entitled "Some Objectives in Styling Farm Machines" by T. H. Koeber, International Harvester Co.

"Frost Protection for Farm Crops" will be the general theme for the Wednesday morning session. George B. Hill, vice-chairman of the Division, will preside.

A contribution from the University of California by F. A. Brooks, C. F. Kelly, D. G. Rhoades, and H. B. Schultz is titled "Heat Transfers in Citrus Orchards Using Wind Machines for Frost Protection."

Results of Michigan State College studies on frost control by means of infrared heaters and horizontal rotating downdraft fans and frost control by sprinkler irrigation will be presented as two separate papers by C. M. Hansen and E. H. Kidder, respectively.

FARM STRUCTURES PROGRAM

"Storage," with special emphasis on some southern requirements, is the opening topic scheduled for attention Monday forenoon by farm structures men. T. E. Long, chairman of the Division, will preside.

Some of the basic science involved will be reviewed by S. M. Henderson, University of California, whose opening paper is titled "Basic Aspects of Equilibrium Moisture." This is to be followed by a paper titled "Results of Sorghum Grain Storage Investigations in the Gulf Coast Area of Texas" by J. W. Sorenson, Jr., and M. Davenport, Texas Agricultural Experiment Station.

Rice is due to receive special attention in the second half of this storage program. "A Study of Humidity and Temperature Conditions in the Gulf Coast Rice Area" by H. Kramer, U. S. Department of Agriculture, will introduce the problem. H. T. Barr and L. G. Coonrod, Louisiana State University, are to follow *(Continued on page 228)*

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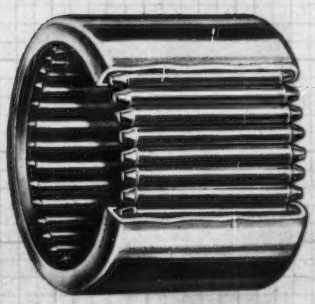

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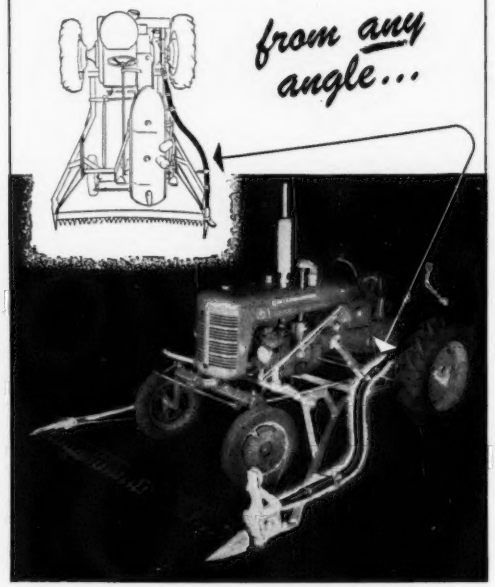
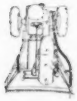


Annis Front End Mower Manufactured by Krengel's, Inc., Twin Falls, Idaho

STOW FLEXIBLE SHAFTING

SOLVES POWER TRANSMISSION PROBLEMS . . . BETTER!



The problem: To provide a means of power transmission between power take-off and mower attachment that would give maximum efficiency — eliminate excessive vibration . . . eliminate danger of exposed rotating parts and costly clogging and jamming caused by dirt, grasses. Stow Flexible Shafting *solves* these problems — transmits power smoothly, safely, economically. Put Stow to work on your problems today!

Send for your free copy . . . Stow Flexible Shafting Bulletin and Torque Calculator.

STOW MANUFACTURING CO.
39 SHEAR ST. BINGHAMTON, N. Y.

NEWS SECTION *(Continued from page 226)*

with a report titled "Present Status of Bulk Drying and Storage of Rice on the Farm."

On Tuesday forenoon, O. K. Otis, vice-chairman of the Division, will preside over a session devoted to three separate phases of farm-housing problems. Use of fans for attic ventilation will be discussed by W. D. Scoates, Texas Engineering Experiment Station. S. R. Weibel, Environmental Health Center, Cincinnati, Ohio, is to report on a study of septic tanks and septic tank disposal systems. Control of decay in buildings will be discussed by A. F. Verrall, U. S. Department of Agriculture.

When the Division reconvenes on Wednesday forenoon for a joint session with the Rural Electric Division, the opening paper will be on "Automatic Controls for Laying Batteries" by S. J. Otis, United Industries. Karl H. Norris, U. S. Department of Agriculture, is scheduled for a paper titled "Radio Frequency as a Means for Grading Eggs." A paper titled "Summer Temperature Control in Dairy Cattle Loafing Barns" by G. L. Nelson, Oklahoma A. and M. College, will conclude the half day devoted to mutual technical interests of the two divisions.

Rural Electric Program

In addition to its joint program with the Farm Structures Division, the Rural Electric Division is planning three meeting periods devoted primarily to the interests of its members. The program has not yet progressed to the point that speakers can be announced, but tentative titles on the subject matter to be covered have been indicated.

For the opening session Monday morning, with D. E. Wiant, chairman, presiding, the program is to include discussions on the status of electrically operated equipment, the importance of the farm service advisor, irrigation in the South and farm publications in relation to extension activities.

The Division will meet again on Monday evening for a program on the relation of electric applications to labor-saving on farms. Tentatively scheduled contributions include a report on a survey to determine essentiality of various items of electrically operated equipment, a discussion on materials handling, and labor-saving devices in the West.

Crop drying and conditioning and refrigeration have been scheduled for discussion Tuesday forenoon. H. S. Hinrichs, vice-chairman, is to preside at that session. Indicated subjects include crop drying in the South, conditioning farm crops with dielectric heating, farm refrigeration, report of a survey on 200 walk-in farm refrigerators, and tests of a small cream cooler.

Soil and Water Program

Location of the meeting in the Southwest is reflected in subject matter emphasized in the Soil and Water Division program.

On Monday morning John L. McKitrick, chairman, will preside and introduce Maurice B. Cox, Soil Conservation Service, U. S. Department of Agriculture, as the opening speaker, on the subject "Terracing Pastures at the Guthrie (Okla.) Station."

John Reid, assistant county agent and M. T. Gowder, University of Tennessee, will follow with a paper titled "Mechanical Techniques for Soil and Water Conservation."

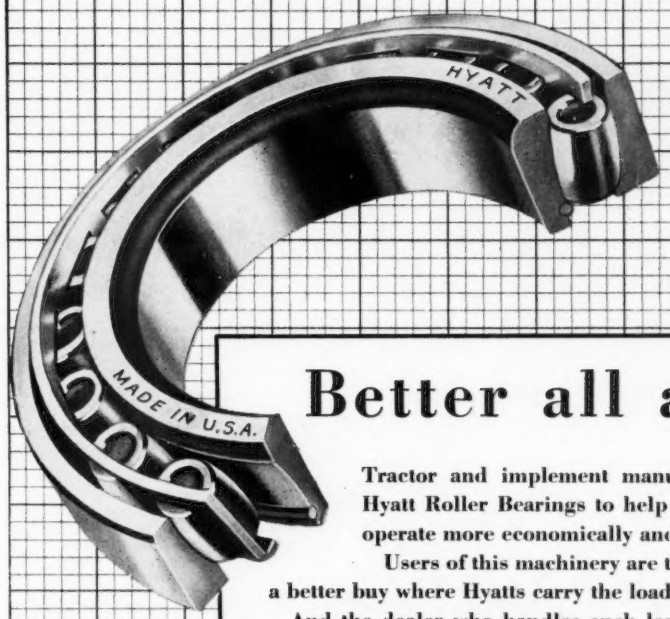
"Making a Creek Flow Gently" is the title under which Howard Matson, Soil Conservation Service, U. S. Department of Agriculture, will report some runoff control operations.

"Soil Survey as a Basis for the Equalization of Rural Assessments" is the subject to be presented by Walter W. Weir, University of California.

In an effort to bring before agricultural engineers some basic data on the much publicized practice of rainmaking, the Division has scheduled for Tuesday morning the presentation of two separate and possibly conflicting viewpoints on the subject. Speaking on behalf of the aggressive development of this means of influencing climate will be a representative of the Water Resources Development Corp., probably Dr. Irving P. Krick. Representing the conservative viewpoint, and calling attention to limitations and to possible dangers and questions of equity in the practice will be a representative of the U. S. Weather Bureau.

R. R. Poynor, vice-chairman of the Division, is to preside at this session. While it is on the subject of rain, the Division will also feature at this session a further contribution on the subject "Splash Erosion" by W. D. Ellison, U. S. Navy.

On Wednesday forenoon M. R. Lewis, chairman of the Committee on Irrigation, will preside over a session devoted to a panel discussion titled "Evaluation of Factors Controlling Soil and Water Relationships Under Irrigation." This is being arranged by George D. Clyde, Soil Conservation Service, U. S. Department of Agriculture. Speakers have not yet been announced, but it has been indicated that the general subject will be broken down into subtopics about as follows: "Plant Response to Fertilizer and Moisture Level," "Soil Moisture Characteristics as they Relate to Movement of Water Through Soil," "Irrigation Requirements of Crops," Water Application Methods and Efficiencies," and "Drainage of Irrigated Land."



Better all around

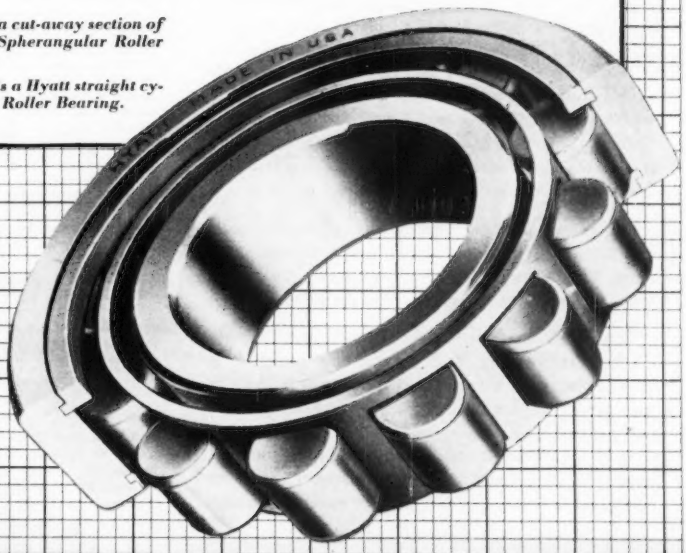
Tractor and implement manufacturers "build in" Hyatt Roller Bearings to help make their machines operate more economically and to last longer.

Users of this machinery are thus assured of getting a better buy where Hyatts carry the loads.

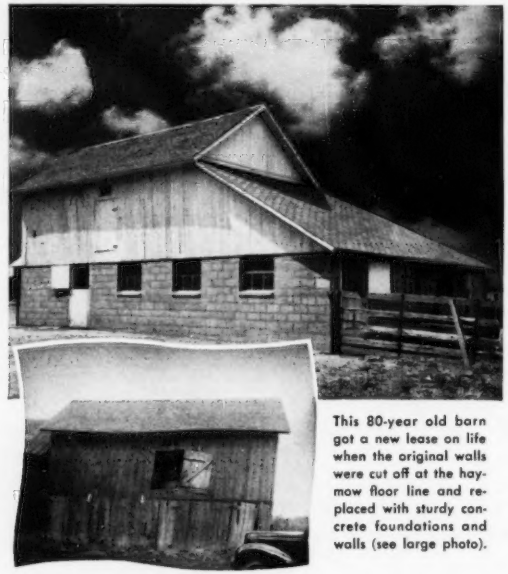
And the dealer who handles such leading lines of tractors and power-farming machines can sell with the confidence of all-around satisfaction. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

Above is a cut-away section of a Hyatt Spherangular Roller Bearing.

At right is a Hyatt straight cylindrical Roller Bearing.



HYATT ROLLER BEARINGS



This 80-year old barn got a new lease on life when the original walls were cut off at the haymow floor line and replaced with sturdy concrete foundations and walls (see large photo).

Add Years of Useful Life to Old Farm Buildings by Remodeling with *CONCRETE*

Agricultural engineers can help farmers add years of usefulness to old buildings by remodeling and modernizing them with concrete. Barns, hog houses, machine sheds and other old farm structures acquire increased efficiency and new life when remodeled with concrete foundations, walls and floors or asbestos-cement siding and firesafe roofs. Such remodeling improves sanitation, reduces maintenance and greatly increases resistance of the structure to storms, decay, rats, termites and fire.

Designing such farm improvements presents both a challenge and an opportunity to agricultural engineers. They must utilize much of the old structures and yet create sturdy, economical buildings.

Concrete's firesafety makes it the logical choice for farm remodeling. And its economy makes it a wise investment. First cost is moderate, upkeep is low, service life long. That adds up to ***low-annual-cost*** construction that soon pays for itself in terms of feed and labor saved, improved sanitation, enhanced livestock health and easier, cleaner and more comfortable living for the farmer and his family.

PORTLAND CEMENT ASSOCIATION
33 W. Grand Avenue, Chicago 10, Illinois
A national organization to improve and extend the uses of portland cement and concrete . . . through scientific research and engineering field work

NEWS SECTION *(Continued from page 228)*

Kline Accepts Ohio Position

C. K. (Cernie) KLINE has resigned his position as assistant secretary of the American Society of Agricultural Engineers effective March 31st, and has accepted an appointment by Ohio State University as extension specialist in rural electrification. In this new position, Mr. Kline will be working with I. P. Blauser and will coordinate the activities of the Ohio Rural Electrification Council in promoting more efficient and effective use of electricity in rural Ohio.

Schroeder New Chairman Southwest Section

E. W. SCHROEDER, head, agricultural engineering department, Oklahoma A. & M. College, was elected the new chairman of the Southwest Section of the American Society of Agricultural Engineers at its yearly meeting held March 23 and 24 at the Grim Hotel in Texarkana. He succeeds Ross R. Mauney, agricultural engineer, Arkansas Power & Light Co.

The new vice-chairman of the Section elected at the meeting is Eugene C. Buie, zone conservationist (SCS), U.S. Department of Agriculture, who has been serving the past year as secretary-treasurer of the Section. Price Hobgood, professor of agricultural engineering, A. & M. College of Texas, was elected the new secretary-treasurer of the Section.

The total registered attendance at the meeting was 96, which included 17 students of agricultural engineering from schools in the Section area. In addition there were 13 ladies who attended the meeting with their husbands.

The main attraction of the meeting was the technical program of papers presented. The program for the opening session on the forenoon of the March 23 included papers by R. S. Williamson, Menge Pump Machinery Co., on pasture irrigation; Leland D. Morgan, Gotcher Eng. and Mfg. Co., on spray equipment for weed and insect control; a representative of General Electric Co. on brooding chicks with infrared lamps; by Howard Matson, chief, regional water conservation division (SCS), U.S. Department of Agriculture, on a comprehensive investigation of the Arkansas-White-Red river basins, and by J. A. Rebentisch, Louisiana State University, on optimum spark settings for propane fuels.

Papers for the afternoon session of the same day were presented by L. R. Raudebaugh, F. E. Meyers and Bros. Co., on the farm and home water supply; by Charlie F. Moore, engineering zone conservationist (SCS), U.S. Department of Agriculture, on improvements in outlet waterway design; by J. S. Tanner, Servis Equipment Co., on procedure and development of a machine; by Ross E. Rogers, sedimentation specialist (SCS), U.S. Department of Agriculture, on recent developments of reservoir sedimentation surveys in the Southwest, and by J. W. Autry, Tarrelton State College, on a simplified method of planting cotton.

The high point of the meeting was the annual Section dinner on the evening of March 23 with Ross R. Mauney, section chairman, as the master of ceremonies. The speaker for the occasion was V. S. Peterson, manager, central west district, Extension Division, E. I. du Pont de Nemours and Co. E. B. Doran, Louisiana State University, contributed to the pleasure of the occasion with the leading of community singing.

The closing session of the meeting on the forenoon of March 24 included three papers, one by W. L. Ulich, Texas Agricultural Extension Service, on farm safety; a second by Chas. E. Ball, associate editor, *Farm and Ranch*, on agricultural engineers and the agricultural press, and a final paper by H. O. Roberts, Central Power & Light Co., on contributions that the agricultural engineer can make to the electric industry.

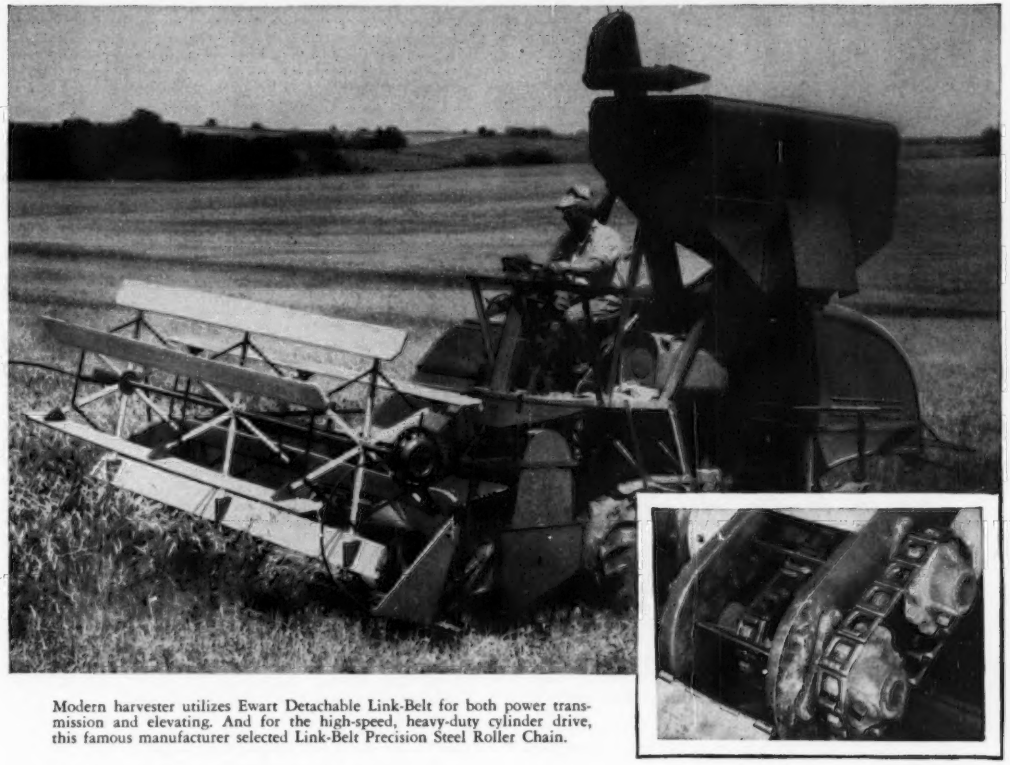
Following these papers the Section business session was held. This was opened by reports from the student branches in the four states comprising the territory of the Section, which was followed by a general business of the Section including the election of officers, and the selection of Texarkana as the place for holding the 1952 Section meeting, on the Friday and Saturday preceding Easter Sunday.

Hawaii Section Program

TWO talks of special interest to agricultural engineers constituted the program of a meeting of the Hawaii Section of the American Society of Agricultural Engineers held March 14 at the Agricultural Engineering Institute of the University of Hawaii in Honolulu, with 25 members of the Society in attendance.

Robert R. Owen, head, agricultural engineering department, Pineapple Research Institute, discussed variable-speed hydraulic drives as a means of eliminating auxiliary engines on field machines. Mr. Owen pointed out that common use of the gasoline auxiliary in conjunction with a diesel propulsion engine complicates the servicing and sacrifices diesel advantages on the auxiliary drive. Mr. Owen described the construction and operation of several fluid clutches, in which the slip is controlled by the operator, which he investigated on a trip to the mainland. *(Continued on page 232)*

no ONE chain serves every purpose



Modern harvester utilizes Ewart Detachable Link-Belt for both power transmission and elevating. And for the high-speed, heavy-duty cylinder drive, this famous manufacturer selected Link-Belt Precision Steel Roller Chain.

LINK-BELT offers the RIGHT chain for every job . . . engineered to meet your requirements

Typical chains from the complete Link-Belt line

Steel Link-Belt for moderate-strength power transmission and conveying.

Class 400 Pintle chain, in malleable or Promal, can be furnished with various attachments.

Double-Pitch Precision Steel Roller chain for low-speed drives and conveyors.

Link-Belt Precision Steel Roller Chain, standard pitch, for high-speed drives.

Link-Belt offers no single "cure-all" chain to handle every job. From the most complete line of agricultural chains and sprockets in the world—we can recommend the exact type to fit your particular design requirements. So, whatever your chain problems, conveying or power transmission, Link-Belt engineers will work with your design engineers to help solve them.

LINK-BELT COMPANY: Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Dallas 1, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Springs (South Africa). Offices, Factory Branch Stores and Distributors in principal cities. 12,321

LINK-BELT

CHAINS AND SPROCKETS

Soil Conservation pays high dividends

FARMERS who established sound soil conservation plans a few years ago are reaping a 25% to 35% dividend in larger crops. They did it on the same ground and with less work after the first year.

If soil conservation pays off so well, why don't all farmers practice it? The answer to that is human inertia. It takes promotion on the part of all those who are interested in improving agriculture. Manufacturers who sell to farmers, county agents, extension services— in fact all who have a stake in agriculture should get behind the soil conservation program.

In order to promote the cause of soil conservation, the American Steel & Wire Company has prepared a complete booklet on the subject. If you would like a copy of this booklet which tells how to establish a soil conservation program, send in the coupon below.

U·S·S American Fence and Wire Products

WOVEN WIRE FENCE — TIGER BRAND WIRE ROPE
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USS
UNITED STATES STEEL

NEWS SECTION (Continued from page 230)

Richard A. Duncan, agricultural engineer, Hawaiian Sugar Planters Assn., reported observations of a recent tour of the southern states with special reference to sugar cane harvesting in Louisiana. Louisiana cane is harvested erect, while in the case of Hawaii and other areas with a continuous growing season much of the cane is recumbent. Louisiana harvesting equipment has consequently not been suited to tropical use according to Mr. Duncan. Current efforts in Louisiana to develop a harvester equally adapted to erect or recumbent cane were described as being of vital interest to cane producers throughout the world.

Iowa-Illinois Section Presents Program

THE Iowa-Illinois Section of the American Society of Agricultural Engineers held a most interesting meeting at the Short Hills Country Club, East Moline, Ill., on March 2 with an attendance of 84 ASAE members and guests.

The opening number of the program was a talk on outboard speedboat racing by Homer Kincaid, Farmall Works, International Harvester Co., in which he gave some most interesting experiences in connection with his 22-year hobby of speedboat racing.

An illustrated talk on oilite bushings and powdered machined parts was presented by Robert Lorimer, district sales representative Amplex Division, Chrysler Motors Corp.

F. W. Duffee, chairman, agricultural engineering department, University of Wisconsin, gave a most interesting talk on looking into the future of farm power and machinery and how design and development affect present trends in thinking and farm practices. Mr. Duffee believes that the tractor of the future should be easier to handle and operate with more power and more efficient operation, and that tractor and implement combinations should be designed to work together with less time required to get the combination ready to work in the field. He also pointed out the need for better chore and field-handling equipment, and it is his opinion that farm mechanization is far from complete. He recommends that engineers of the farm equipment industry work more closely with agricultural experiment stations which are developing new crops and improving present ones so that machinery will better fit actual requirements now and in the future.

Alabama Section to Meet and Fish

THE Alabama Section of the American Society of Agricultural Engineers will hold its annual spring meeting at Gulf Shores on May 11 and 12. An attractive program will feature representatives from industry who will describe new developments and techniques in farm housing, farm machinery, rural electrification, and soil and water. The new date, a month later than last year's meeting, will also find all varieties of game fish on the run, according to the "experts". Members who attended last year's meeting will remember the fun which will be repeated this year, but in addition each member is cautioned that he is responsible for bringing adequate facilities to transport his catch home.

News From Moscow (Ida.)

THE agricultural engineering department of the University of Idaho at Moscow is apparently on the march. The head of the department, J. W. Martin, reports that they have just moved into a new engineering classroom building which houses the offices and classrooms for all engineering instruction on the campus. It is a five-story building, and the department staff feels fortunate in being able to occupy the new building along with the civil, mechanical, and chemical engineers. The department expects also to move into their new agricultural engineering laboratory building about July 1st.

Wanted: Information on Experimental Fertilizer Placement Equipment

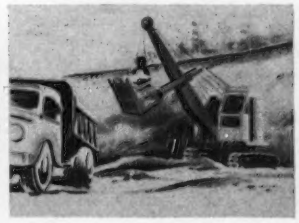
THE 1950 proceedings of the 26th annual meeting of the National Joint Committee on Fertilizer Application (of which ASAE is one of the sponsor organizations) includes a compilation of a partial list of experimental equipment for the placement of fertilizer. The Subcommittee on Machinery for Research of the National Joint Committee, in compiling this list of experimental equipment, attempted to secure information on all such equipment in each state, but feels that its efforts were not completely successful. The Subcommittee therefore invites experiment station workers to report other machines not included so that they may be added to a revised compilation. Copies of the NJCFA proceedings may be obtained from the offices of the National Fertilizer Association, 616 Continental Bldg., Washington 5, D. C. Information on experimental fertilizer placement equipment not included in the 1950 NJCFA proceedings should be sent to the chairman of the Subcommittee on Machinery for Research, O. C. French, agricultural engineering dept., Cornell University, Ithaca, N. Y.

More Efficient Equipment comes from INDUSTRY WORKING WITH CLARK

When a manufacturer of agricultural or industrial machinery decides to work with Clark, with a purpose to develop better equipment, a successful result is almost a certainty. That pooling of the experience and engineering facilities of two competent organizations has been tried many times; and without exception, effective teamwork has produced a machine of exceptional efficiency and long life.

A potent factor in these successes is the Clark Engineering Laboratory with its unsurpassed testing facilities—to prove that the new equipment will perform in actual service with the thorough dependability expected of it.

This sound collaborative service is available to you—with impressive evidence that it will benefit you as it has others. You'll find it "good business" to find out about it —no obligation, of course.



CLARK EQUIPMENT COMPANY, Buchanan, Michigan *Other Plants:* BATTLE CREEK AND JACKSON, MICHIGAN

PRODUCTS OF CLARK—TRANSMISSIONS FORK TRUCKS & TRACTORS AXLE HOUSINGS
GEARS AND FORGINGS RAILWAY CAR TRUCKS ELECTRIC STEEL CASTINGS
FRONT AND REAR AXLES FOR TRUCKS AND BUSSES METAL SPOKE WHEELS TRACTOR UNITS

Howard Everett Heads ASAE Mid-Central Section

HOWARD E. EVERETT, editor and vice-president, *Implement and Tractor*, Kansas City, Mo., was elected the new chairman of the Mid-Central Section of the American Society of Agricultural Engineers at the annual meeting of the Section held this year on the campus of the University of Missouri at Columbia. He succeeds J. C. Wooley, professor of agricultural engineering, University of Missouri. The three new vice-chairmen of the Section elected at the meeting include L. W. Hurlbut, head, agricultural engineering department, University of Nebraska; A. W. Zingg, project supervisor, wind erosion mechanics research, U.S. Soil Conservation Service, and K. B. Huff, professor of agricultural engineering, University of Missouri. The new secretary-treasurer of the Section is John M. Ferguson, extension agricultural engineer, Kansas State College. The nominating committee for the ensuing year is L. W. Hurlbut (chairman), F. C. Fenton, and M. M. Jones. The Section voted at its meeting to hold the 1952 Section meeting at Kansas City.

The formal program of the meeting at Columbia opened on the forenoon of March 22 with a welcome to the University of Missouri by H. O. Croft, dean of engineering. This was followed by a talk by Extension Director J. W. Burch of Missouri on balanced farming in the state. The water management phase of the Missouri balanced farming program was presented by M. W. Clarke, extension agricultural engineer of Missouri. This was followed by a demonstration of model erosion control structures by H. J. Hall and R. P. Beasley of the University of Missouri. A collapsible form for drop inlets was the title of the paper by C. L. Dickinson of the U.S. Soil Conservation Service. D. D. Smith of the SCS division of research presented a paper on subsoil conditioning on claypan for water conservation.

The afternoon program opened with a talk on the psychroenergetic laboratory at the University of Missouri by Harold Thompson, USDA agricultural engineer. Following a trip through the laboratory, Mr. Thompson and Dr. Samuel Brody of the University of Missouri dairy husbandry department reported on some of the results of the laboratory to date. The concluding number of the afternoon program was a paper by K. B. Huff of the University of Missouri on meeting sanitation requirements in dairy barn design.

Concurrently with the afternoon program the students attending the meeting held a student paper contest.

The Section dinner was held during the evening of the first day with Paul N. Doll as master of ceremonies. The dinner speaker was Fred. C. Fenton, ASAE President. Following President Fenton's talk the author of the winning student paper contest presented his paper to the group. The showing of a motion picture, entitled "Missouri's Natural Resources" concluded the dinner program.

The concluding session of the meeting, on the forenoon of March 24, included papers by G. H. Larson, Kansas State College, on LP gas as a tractor fuel; by J. J. Sulek, University of Nebraska, on engineering laboratory tests of LP gas vs. gasoline; by V. J. Butler, University of Missouri, on the results of a survey of farmer experience in Missouri in using LP gas; by F. D. Yung, University of Nebraska, on bin curing of high moisture grain; by C. A. Reaves, University of Missouri, on research in the heating of dwellings; by P. L. Lyman, Kansas State College, on experimental results with the heat pump, and by Robert George, Consolidated Electric Coop., on rural electrification problems.

Washington Section Has Ladies' Night Meeting

THE annual ladies' night program of Washington (D.C.) Section, ASAE, was held in the Potomac Electric Power Co.'s Pepco auditorium Friday evening, March 9. Approximately fifty members, wives, and guests were in attendance, including several members of the armed services on duty in the area.

The meeting chairman, E. L. Arnold, introduced the program, beginning with Fred McVey, magician, who practiced successfully the art of legerdemain, to the amazement of the enthusiastic audience and the embarrassment of the meeting chairman and an unnamed guest.

Miss Louisan Mamer, REA lighting specialist, showed many types of lamps and wall and ceiling fixtures. Colored slides showed their application to various rooms and locations in the home in relation to proper illumination and aesthetic principles. Demonstration of sources of light and the principles involved in good illumination were set forth in terms of lighting recipes. These were further emphasized in a pamphlet distributed to all those in attendance.

Michigan Section to Meet in Toledo

THE spring meeting of the Michigan Section of the American Society of Agricultural Engineers is to be held Saturday, May 5, at the Toledo Edison Company Club near Maumee, a suburb of Toledo. The address of the Club is 1036 River Road, State Route 25. The principal features of the program for the occasion will be a paper and demonstration of electrostatic precipitation of dusts and a second paper on *(Continued on page 236)*

The POWER ADVANTAGE Story of the Model AEN Single Cylinder WISCONSIN *Air-Cooled* ENGINE

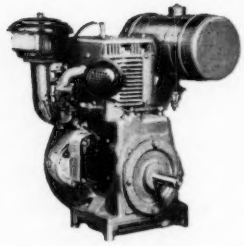
Here's more power . . . less weight . . . lower cost . . all with no sacrifice in heavy-duty construction and serviceability in this Model AEN single-cylinder Wisconsin Engine. Features include:

1. Dependable air-cooling under all climatic and weather conditions.

2. Self-cleaning tapered roller bearings at *both* ends of the crankshaft withstand either side-pull or end-thrust without danger to bearings.

3. Rotary type high tension OUTSIDE Magneto with Impulse Coupling operates as an entirely independent unit that can be serviced or replaced in a few minutes.

4. Maximum torque at usable speeds for equipment that really has to go to work.



Model AEN 4-cycle single cylinder standard engine.

SPECIFICATIONS, MODEL AEN

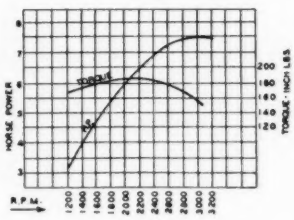
Bore	3"
Stroke	3¼"
Piston Displacement	23 cu. in.
Horsepower	5.1 H.P. at 1800 R.P.M. 6.4 H.P. at 2200 R.P.M. 7.2 H.P. at 2600 R.P.M. 7.5 H.P. at 3000 R.P.M.

WHEN ORDERING ENGINE SPECIFY SPEED DESIRED

Diameter of Valves	1-5/16" O. D.
Spark Plug size	18 mm. Metric
Fuel Tank Capacity	1.7 Gals.
Valve Location	L-Head
Piston Pin Diameter	¾" Floating Type
Conn. Rod — Steel Forging	Length 8"
Conn. Rod Bearing	1⅛" x 1¼"
Oil Required in Reservoir	3 Pts.
Cylinder Head	Aluminum, Removable
Cylinder — Crankcase	Cast Iron
Valve Seat Inserts	Nickel Chrome Molybdenum Iron
Piston	Aluminum Alloy
No. of Piston Rings	4
Main Bearings	Tapered roller of generous size
Crankshaft	Counterbalanced Heat Treated Drop Forging

Weight-Lbs.	Net	Crated
Standard Engine	110 Lbs.	135 Lbs.

Second of a series about Wisconsin Engines. For more detailed information and for the entire series, write us.

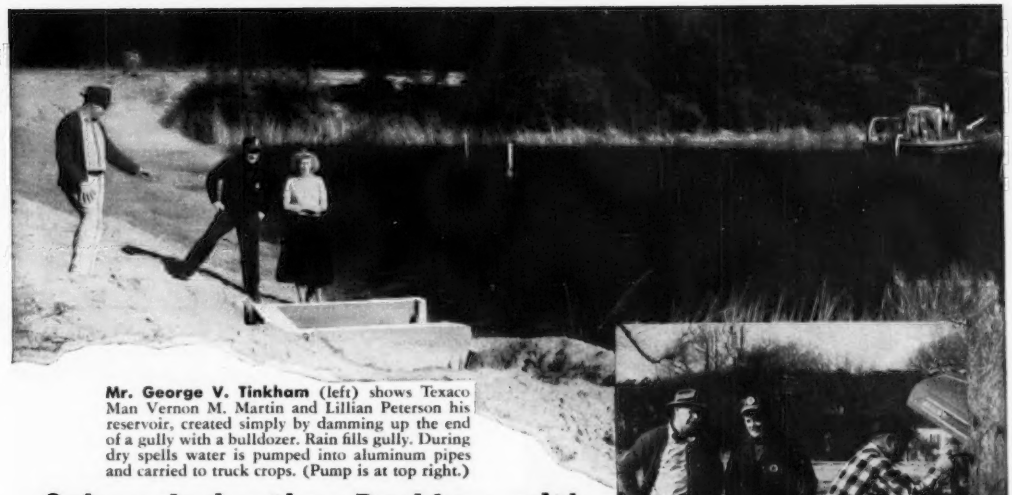


POWER CURVE AND HORSEPOWER LISTING SHOWS MAXIMUM DYNAMOMETER HORSEPOWER OF ENGINE complete with fan, muffler and air cleaner. For continuous heavy-duty operation do not rate engine at more than 80% of the horsepower shown at any given speed.

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

MILWAUKEE 46 WISCONSIN



Mr. George V. Tinkham (left) shows Texaco Man Vernon M. Martin and Lillian Peterson his reservoir, created simply by damming up the end of a gully with a bulldozer. Rain fills gully. During dry spells water is pumped into aluminum pipes and carried to truck crops. (Pump is at top right.)

Solves Irrigation Problem with "Homemade" Pond, Pump and Movable Pipe Lines

Mr. George V. Tinkham, progressive truck farmer near Cape Charles, Virginia, has solved the problem of "dry spells" on his farm on the famous Del-Mar-Va Peninsula, home of "frozen foods."

He simply dammed up the end of a gully, and it filled with water during rainy weather. When dry periods come along, he pumps the water into easy-to-move aluminum pipes and irrigates the land. Mr. Tinkham grows some fine crops as a result.

Like outstanding farmers the country over, Mr. Tinkham has also found that *it pays to farm with Texaco Products.*

Mr. Tinkham chats with Texaco Man Martin as Mr. C. Murdock pours in some Havoline, the motor oil that's better than Premium grades—even exceeds heavy duty requirements. Havoline is ideal for gas or Diesel tractors as well as cars and trucks.

This novel tractor-planter on the Emilie plantation near Lions, Louisiana, is getting the right lubricant—Marfak. There is none better for tractor, truck, car or farm machinery; for Marfak resists jar-off, water-wash, rust, and clings to bearings longer. Texaco Men Alvin Crais and Walson Tassin watch Carl Levet, plantation owner, put Marfak on the job.

"Cherry Bowl" near The Dalles, Oregon, gets Texaco Service. Earl Curtiss (left) of Curtiss Bros., who produce 1,000 tons of cherries a year in their orchards, finds it pays to use Texaco Gear Lubricant EP and other Texaco Products. Texaco Man Bob Brown (right) gives the kind of service farmers want.

Extra power for low-cost operation — that's what Texaco Fire-Chief gasoline gives to tractor, truck or car. That's why Mr. G. Alex Bailey, a ten-truck farmer of Potosi, Wisconsin, is getting a delivery of Fire-Chief from Texaco Man Allen Austin.

See the full-color film "TEX"—The Story of a Champion Calf—shown at Texaco Farm Meetings. Ask your Texaco Man about it.

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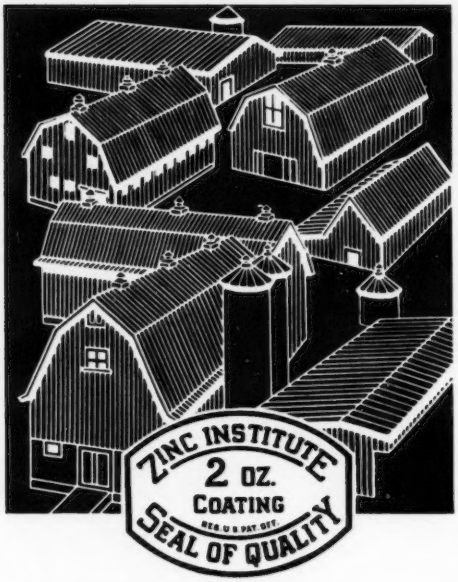

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NEWS SECTION *(Continued from page 234)*

drainage and its effect on wild life. A cordial invitation is extended to all ASAE members, both within and outside of Michigan to attend this meeting, and a special invitation is extended to ASAE members in Ohio and northeastern Indiana. Details regarding the program for the meeting may be obtained from the Section secretary, Paul E. Schleusener, Agricultural Engineering Building, Michigan State College, East Lansing.

PERSONALS OF ASAE MEMBERS

Harold H. Beaty has resigned as extension and research associate professor of agricultural engineering at Iowa State College to accept appointment as rural service manager of the Edison Electric Institute in New York City. He has been associated with rural electrification work in Iowa since 1936.

Joel R. Benjamin, who operates under the firm name of Water Management, is taking a six-months graduate course in pond and lake maintenance and advanced drainage at Ohio State University, and has moved his headquarters from Medina, to Chagrin Falls, Ohio. His organization is expanding its activities to include pond and lake construction, maintenance and management, and drainage system planning.

Allison W. Blanshine, formerly design engineer with The Oliver Corp., Battle Creek, Mich., recently arrived in Honolulu to take up his duties as associate agricultural engineer with the Hawaiian Sugar Planters Assn's. experiment station.

Charles W. Hart, Jr., recently arrived in Honolulu, having accepted the position of associate agricultural engineer with the experiment station of the Hawaiian Sugar Planters' Assn. He was formerly junior design engineer with the Towner Mfg. Co., Santa Ana, Calif.

George V. Keller has recently established the Keller Agricultural Service, featuring farm management, real estate, loans, and insurance. He is located at Lexington, Neb., where he was formerly associated with Walter T. Dunlap and Co., as a pump irrigation engineer.

M. R. Lewis, chief, division of irrigation operations, branch of operations and maintenance, Bureau of Reclamation, U.S. Department of the Interior, is one of the ten technicians who are completing orientation courses at the Foreign Service Institute of the U.S. Department of State before joining a Point Four missions in several different countries. He is going to Lebanon on the Point Four project to develop the Litani River Valley.

Daniel C. McCoy, general sales department, Frigidaire Division, General Motors Corp., was editor-in-chief of the 1950 Applications Volume of the Data Boow of the American Society of Refrigerating Engineers.

George C. Merkel, formerly sales and service engineer, Innes Company, Bettendorf, Iowa, is now engaged in the farm building business under the firm name, Gordon Engineering Service. The business includes the sale and erection of steel buildings for farm and industry, the erection of prefab homes, and private engineering, including the making of land surveys, etc. The business is located at Oskaloosa, Iowa.

Archie A. Stone has resigned as special representative, executive offices, International Harvester Company, to accept appointment as chief of the farm equipment section of the Office of Price Stabilization at Washington, a position similar to the one held in OPA during World War II. It is understood that he is on temporary leave from his position with the Harvester Company.

Necrology

ROBERT R. ROBINSON, president, Robinson Ventilating Co., Zelienople, Pa., passed away January 25, at the age of 59. He was born at Monongahela, Pa., and received his BS degree at Pennsylvania State College in 1913. He farmed for four years, and then entered the army for service in World War I. After the war, he went to Washington for his health and remained there until 1923. On his return to the Pittsburgh area at that time, he joined his father's ventilating equipment manufacturing business with which he was associated until his passing. The business supplies ventilating systems for coal mines, mills, and factories, dust-collecting systems, driers for ceramic wares, and in recent years, farm building ventilating equipment. In his work he retrained himself as an engineer to the extent of qualifying for and being registered as a professional engineer. Growing interest in farm building ventilation and contacts with other agricultural engineers led to his becoming a member of the American Society of Agricultural Engineers in 1947. He was also a member of the American Ceramic Society, Canadian Ceramic Society, Pennsylvania Ceramic Association, and Pennsylvania Society of Professional Engineers. In addition he was president of the Mahoning-Shenango Valley Engineering Society and a director of the Smaller Manufacturers' Council of Pittsburgh. He had become president of the Robinson Ventilating Company last year, succeeding his father, following extended service as its general manager. He is survived by his widow, Mrs. Marie McDermott Robinson, two sons, James R. and Neal R. Robinson, two sisters and three brothers.

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A Correction

TO THE EDITOR:

I SEE that in my article, entitled "Distribution of Air in Refrigerated Apple Storages," published in AGRICULTURAL ENGINEERING for January, 1951 (pp 41, 42), I made a regrettable omission.

Although I mentioned that the paper is based largely on a previously published pair of papers, I somehow omitted to acknowledge that these papers originated from the Dominion Experimental Station, Summerland, B. C.

This is most unfortunate inasmuch as the Experimental Station not only administers the Growers Association's research grant, but supplied facilities, instruments, and both professional and non-professional help.

Hence I would be grateful if you would publish this letter in order to correct the oversight.

W. GRIERSON-JACKSON

Ithaca, N. Y.

Basis for Estimating Runoff

TO THE EDITOR:

AS AN engineer in the Soil Conservation Service of New South Wales in Australia, I am naturally interested in U.S. developments and trends of thought in regard to the problem of runoff and soil erosion.

Although I am exceedingly late in entering the field, I would like to add a word of comment to the discussion, following an article, entitled "Runoff Estimates Based on Infiltration Capacity, Antecedent Moisture Conditions and Precipitation," by R. G. Andrews in the AGRICULTURAL ENGINEERING for January, 1950.

I agree with Mr. Andrews in principle that the infiltration capacity and antecedent moisture conditions of a soil is the best basis for estimating runoff, and I note that the procedure given has been favorably received by three of the most prominent soil erosion specialists in the U.S.A.

It is noted also that all three specialists observed the same "defect", namely, the placing of infiltration curves at different values of f_c for the same soil complex.

It would be interesting to know if any data has since come to light to settle this matter one way or the other. For myself, I feel that the infiltration rate at f_c should have substantially the same value for the same soil complex, because the effect of antecedent moisture conditions is expected to be less and less as the soil gets wetter and wetter.

Unless I have misunderstood the procedure, it contains a much more serious defect than the one mentioned.

In Figs. 2 and 3 it is tacitly assumed that runoff and infiltration requirements are completely satisfied at the moment precipitation ceases.

By definition, *Pe*, in Figs. 2 and 3, is the depth of precipitation which fell at a rate in excess of any selected intensity. The assumption is that if the "selected intensity" corresponds with the rate of infiltration obtained from infiltration capacity curves (Fig. 4), then *Pe* corresponds with the depth of runoff.

In fact, *Pe* corresponds with surface storage accumulated at the end of precipitation.

This is not the same thing as runoff, because the surface-water accumulation remains after rain has ceased and an additional period of time must elapse during which a portion of the surface-water flows away as "runoff" and a portion infiltrates below the surface.

Accordingly the value *Pe* in Fig. 2 must be further reduced by the amount of infiltration occurring *after* rain has ceased before it can fairly be regarded as "runoff".

The only difficulty in assessing the amount of infiltration occurring after rain ceases is in estimating the period for which flowing water remains on the surface before it is exhausted by the requirements of "runoff" and "infiltration". Close examination of hydrographic records from catchments of all sizes may provide a practical means of estimating the duration of runoff after cessation of rain. For example, it could be found that the least duration of runoff after rain has ceased is some nearly constant proportion of the duration of the corresponding rainfall.

Consideration of a few hydrographs leads me to believe that runoff would continue after rain ceases in a majority of cases, for a period not less than the duration of the corresponding rainfall.

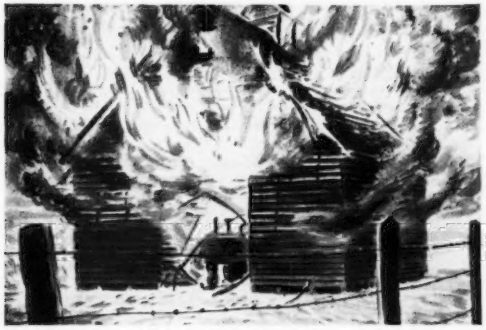
Using the lowest infiltration capacity corresponding with $\Sigma=7$ for the yahola soil complex, the infiltration rate after rain ceases would be 0.5 iph. The period of infiltration (or runoff) *after* cessation of rain would be 2.16 hr. The additional amount of infiltration *after* cessation of rain would be 1.08 in. The corresponding amount of runoff, in the example of Fig. 5, would be 2.25 in less 1.08 in.

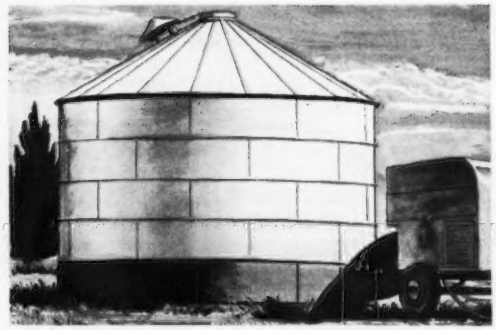
Runoff would therefore be 1.17 in instead of 2.25 in for the example quoted.

I would be interested to obtain the views, respectively, of Mr. R. G. Andrews, Mr. L. K. Sherman, Mr. Edgar E. Foster and Mr. W. W. Horner on this aspect of the procedure under discussion, if they would be so good as to write to me.

E. G. CONNOLLY

5 Terminus St., Liverpool, N. S. W., Australia





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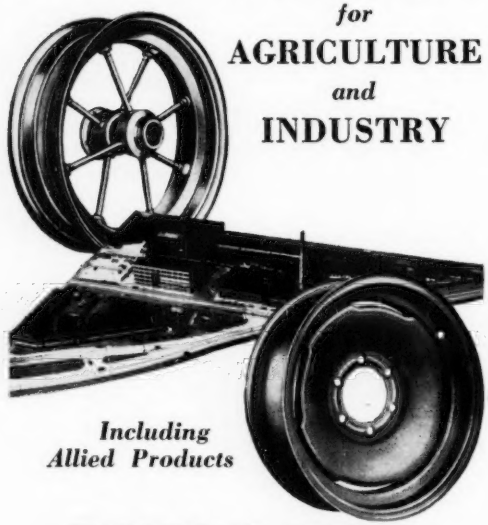

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Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Baijal, Prem N.—Foreman, well-sinking scheme, agricultural dept., State of Ajmer, India. (Mail) Shivapuri, Hathibhata

Bender, Frederick G.—Partner, Jacob Bender & Sons, Sutton, Nebr.

Brandenburg, Harold S.—Graduate assistant, University of Ill., Urbana, Ill. (Mail) 1107 West California

Campbell, Richard H.—Managerial trainee, Opekasit Center, Hamilton, Ohio. (Mail) 734 Dayton St.

Catoni, Pedro—Student in agr. eng., Southwestern Louisiana Institute, Lafayette, La. (Mail) Box 245

Dohl, Torrence W.—Agr. engr., New Holland Machine Co. (Mail) c/o Hillcrest Manor Motel, New Cumberland, Pa.

Horner, Robert D.—Manager, irrigation dept., Hilton Co., 1091 N. 48th St., Milwaukee, Wis.

Johannsen, Bruno B.—Proj. engr., John Deere Waterloo Tractor Works, Waterloo, Iowa

Johnson, Howard K.—Assistant manager, Oliver Mfg. Co., Rocky Ford, Colo. (Mail) Box 512

Lonberger, John Pickard—Dist. mgr., Goulds Pumps, Inc., Tulsa, Okla. (Mail) R R 3, Box 65 A

McCleary, John G.—Chief inspector, New Holland Machine Div., The Sperry Corp., Belleville Plant, Belleville, Pa.

Merryweather, George T.—Tech. asst., agr. & ind. tire div., Goodyear Tire & Rubber Co., Ltd., Wolverhampton, Eng. (Mail) 63 Albert Rd.

Messinger, Clyde U.—Asst. production mgr., Messinger Mfg. Co., Tatamy, Pa. (Mail) Box 64

Mohler, Frank C.—Field engr. (SCS), USDA, Fulton, Mo.

Redetzke, Emery C.—Production engr., J. I. Case Co. (Mail) 920 4th Ave., Moline, Ill.

Roy, Wilfred A. J.—Engr. draftsman, Giffels & Vallet, Inc., Detroit 21, Mich. (Mail) 15811 San Juan Dr.

Sayler, Robert L.—Agr. engr. (SCS), USDA, P.O. Box 992, San Angelo, Tex. (Mail) 1414 Tyler St.

Smith, Douglas V.—Sales engr., Industrial Pump Corp., 2nd Ave. at 18th St., Tampa, Fla.

Stagers, Ennes D.—Draftsman, engineering dept., International Harvester Co., East Moline, Ill.

Suim, Harold N., Jr.—Sr. draftsman, John Deere Des Moines Works, Ankeny, Iowa

Thomas, David E., Jr.—Supervisor, filament dept., Sylvania Electric Products, Inc. (Mail) 440 Locust St., Roaring Springs, Pa.

Thornton, Charles S.—Asst. plant superintendent, Tennessee Valley Coop, Inc., Decatur, Ala. (Mail) 9C Sheridan Apts.

von Sybel, Hans—Director, institute of agr. eng., Tech. Academy of Munich, Germany. (Mail) Munchen 9, Asamstr. 8 III

Waurzyniak, Richard L.—Trainee (SCS), USDA. (Mail) 1007 S. Main St., Clinton, Ind.

TRANSFERS OF MEMBERSHIP GRADE

Black, Donald T.—Agr. engr., USDA. (Mail) Agr. Eng. Bldg. I, University of Maryland, College Park, Md.

Campbell, John C.—Ext. spec. in rural housing, agr. eng. bldg., Oregon State College, Corvallis, Ore.

Honnold, Arthur C.—Proj. engr., Wood Bros. Inc., Des Moines, Iowa. (Mail) 1518 Osceola Ave.

NEW BULLETINS

Progress Report of the Washington Farm Electrification Committee, 1950, by W. E. Matson and J. Roberts. This 26th annual report covers poultry brooding studies and dairy calf housing.

Subsidence of Muck Soils in Northern Indiana by H. A. Jongedyk, R. B. Hickok, I. D. Mayer, and N. K. Ellis. Purdue Agricultural Experiment Station (Lafayette, Ind.) Bulletin SC 366 (November, 1950). Discusses causes, rates, amounts and control of subsidence.

Solar Radiation Investigations in Michigan, by George A. Crabb, Jr. Technical Bulletin 222 (October, 1950) Michigan State College (East Lansing). A preliminary report on a continuing approach to basic data on hydrologic relationships of typical Michigan soils, under various land uses. This work devoted largely to solar radiation measurement is a start toward quantitative correlation between it and soil moisture losses by evaporation and possibly other hydrologic phenomena. A comprehensive bibliography is included.

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	Grade	Tensile strength, psi	Yield strength, psi	Elongation per cent	BHN	Usual condition
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B	80-60-05	85/95000	65/70000	5.5/10.0	195/225	As-cast
C	60-45-15	65/75000	50/60000	17.0/23.0	140/180	Annealed
D	80-60-00	85/95000	65/75000	1.0/3.0	230/290	As-cast

A Pearlitic in structure. Provides good mechanical wear resistance.

B Pearlitic-ferritic in structure. Provides strength and toughness combined.

C A fully ferritic structure usually obtained by short anneal of either (A) or (B). Provides optimum machinability and maximum toughness.

D Higher phosphorous content than preceding grades, also higher manganese. Provides high strength and stiffness, but only moderate impact strength.

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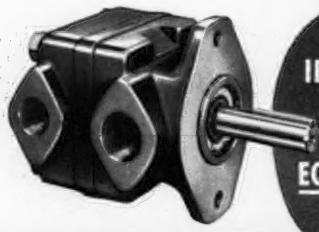

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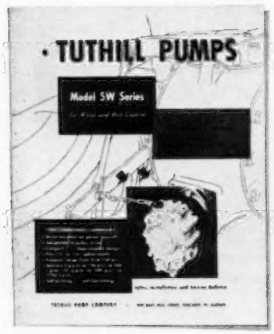

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Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this bulletin the following listings still current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated:

POSITIONS OPEN: OCTOBER—O-76-508, O-46-509. NOVEMBER—O-102-510. DECEMBER—O-113-514. 1951—FEBRUARY—O-158-516, 168-517, 173-518, 150-519, 150-520. MARCH—O-174-521, 186-522.

POSITIONS WANTED: SEPTEMBER—W-40-10. OCTOBER—W-69-13, 73-14, 71-15. NOVEMBER—W-72-17, 99-18. DECEMBER—W-114-22. 1951—JANUARY—W-106-24, 140-25, 145-27. FEBRUARY—W-148-29, 151-30, 156-31, 152-32, 162-33, 163-34, 164-35. MARCH—W-116-36, 120-37, 171-38, 172-39, 184-40, 176-41, 185-42, 188-43.

NEW POSITIONS OPEN

FIELD REPRESENTATIVE and director of research and promotion with trade association in farm structures field. Location Chicago or vicinity. Work primarily with colleges, extension services and leaders of 4-H Clubs and vocational agriculture teachers. BS deg in agricultural engineering or agriculture, with major in farm structures field. Experience in sales management, advertising, publicity, or agricultural extension work. Usual personal qualifications. Must be willing to travel. Age 35-45. Salary open. Traveling expenses paid. O-177-523

AGRICULTURAL ENGINEER for research work, largely in farm structures field, in Alaska. Includes taking data on research projects now in progress; planning new projects in cooperation with the agricultural engineer in charge; and general duties connected with research work. BS deg in agricultural or mechanical engineering. Farm background. Personal honesty and loyalty to superiors and subordinates. Opportunities for advancement excellent. Housing not furnished and scarce at present. Age 25-45. Salary, GS-7 or GS-9 rating plus 25 per cent cost of living differential. O-193-524

AGRICULTURAL ENGINEER (professor or associate professor rank) for teaching and research in agricultural engineering department head capacity in an eastern Canadian agricultural college. MS deg and several years experience in the agricultural engineering field. Age, under 50. Salary $5000 present minimum (cost of living considered, this is believed equivalent to $6000+ in the U.S.A.) O-226-525

JUNIOR ENGINEER EXAMINATIONS

The U. S. Civil Service Commission has announced new examinations for junior engineer and junior scientist ratings in grades GS-5 and GS-7. The GS-5 rating requires a BS deg in an engineering curriculum of 4 yr or longer, or an equivalent combination of training and experience. Base pay is $3100. The GS-7 rating requires the above plus completion of all scholastic requirements for an MS degree in engineering, or equivalent experience. Base pay is $3825. Age limits are 18 to 35 years for the GS-5 rating and 18 to 62 years for the GS-7 rating. Age limits are waived for veterans. Written tests are not required. Interested applicants should file applications including Form 57, card form 5001-ABC, and in the case of veterans, Form 14. Forms may be obtained from any first or second class post office. Applications should be mailed to the U.S. Civil Service Commission, Washington 25, D.C. They will be accepted until further notice. Persons who attained eligible ratings under Announcement No. 250, issued in October, 1950, and who have not yet received an appointment, need not apply as their eligibility will be continued.

NEW POSITIONS WANTED

DESIGN, developemnt, or research in the power and machinery or rural electric field with manufacturer or in federal service, anywhere in U.S.A. BS deg in agricultural engineering expected in June, North Carolina State College, with major in power and machinery option, including rural electrification. Part time work as carpenter and as electrician's apprentice while in college. War service in Navy 3½ years as aircraft mechanic, carburetion specialist. Married. Age 28. No disability. Available June 20. Salary open. W-196-44

DESIGN, teaching, or research in power and machinery, with manufacturer or in public service, any location. BS deg in agriculture, 1948; BS deg in mechanical engineering, 1950; MS deg in mechanical engineering expected June, 1951, all at University of Wisconsin. Wisconsin farm background. Instructor in power and machinery half time 2 years. Research assistant full time one summer. Enumerator U.S.D.A. farm electrification survey one month. War noncommissioned service in Army Air Force, 4½ years, including 2 years as aviation mechanic and 2 years as instructor in aircraft engines. Married. Age 34. No disability. Available July 1. Salary $4000-4600. W-197-45

MANAGEMENT, development, research, extension, teaching, service, or writing, in power and machinery, soil and water, product processing, or farm management, with preference for work in connection with irrigation. Interested in private industry or public service, with location in West, Southwest, South, Hawaii, Costa Rica or possibly other Central American countries. BS deg 1939, Southwestern Institute of Technology, with majors in biological and physical science. BS deg in agricultural engineering, 1946, Oklahoma A & M College. MS deg in agricultural engineering, 1947, A & M College of Texas. Part time graduate study in soils, New Mexico A & M College 1949. Speak Portuguese well, Spanish slightly. Experience, June 1950 to present, assistant director in Brazil, American International Association; May 1948 to June 1950, head of agricultural engineering department and irrigation research, New Mexico

(Continued on page 244)

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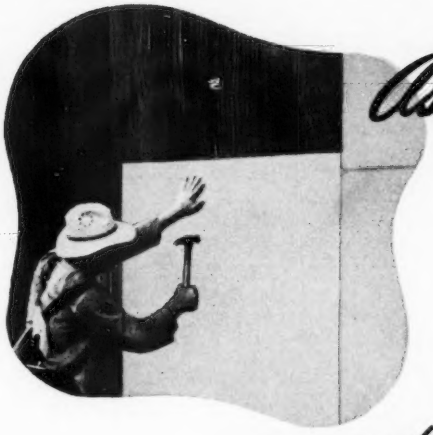

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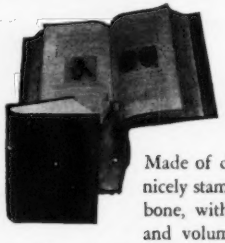

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RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

PERSONNEL SERVICE BULLETIN

(Continued from page 242)

A & M College. Farm background and other previous teaching, engineering and consulting experience. War commissioned service in U.S. Navy 4 years, including one year in aerial photography, 3 years in design of aircraft camera installation and modification of aircraft for photography. Not subject to recall. Married. Age 34. No disability. Available on 90 days notice. Salary $6000. W-202-46

EXTENSION, teaching, research, or writing, in farm structures or soil and water field, in industry or public service. BS deg in agriculture, 1948, Ontario Agricultural College. MS deg in agriculture, 1950, University of Toronto. General farm background. Two summers in implement factory on assembly, repair, and drafting. Two years half-time teaching, research, and extension in rural sanitation and farm buildings. Full time research assistant 6 months, agricultural engineering department, Ontario Agricultural College. War service 3 years in R.C.A.F., retiring as pilot officer and navigator. Married. Age 29. Wear glasses for minor vision defect. Available now. Salary open. W-227-47

DESIGN, development, research, or writing in farm structures or soil and water field, in industry or public service, east of the Mississippi River, preferably in the Southeast. BS deg in agricultural engineering expected in June, Clemson College. Farm background. Aircraft model maker one year with National Advisory Committee for aeronautics. Construction work one year. Agricultural engineering aid on irrigation project one summer. War enlisted service in Navy 1¼ years, aviation electrician. Married. Age 26. No disability. Available June 2. Salary open. W-212-48

EXTENSION, teaching, or research in rural electric or product processing field in public service, preferably in Midwest or Northwest. BS and MS deg in agricultural engineering, 1948 and 1951, Iowa State College. Farm background, including 2 years of active farm operation. Part time, 7 months, design and drafting of farm structures, assistant laboratory instructor in farm structures 6 weeks. Instructor, December 1948 to present, in rural electrification, farm power and machinery, and dairy engineering. War enlisted service in Air Force, 4 years. Married. Age 32. No disability. Available August 1. Salary open. W-222-49

DESIGN, development, or research in farm structures or product processing, in industry or public service, anywhere in the U.S.A. BS deg in agricultural engineering, 1949; MS deg in industrial engineering expected in June, both at Purdue University. Farm background. Factory work one summer. Research in hay drying 1948 to present. Research fellow in agricultural engineering, on hay drying, structures, and farm work simplification while working for MS deg. War enlisted service in Signal Corps. Married. Age 29. No disability. Available June 15. Salary open. W-229-50

DESIGN, development, or research in power and machinery field, with industry, anywhere in the U.S.A. BS deg in agricultural engineering expected June 18, University of Maine. Farm background. Tested aircraft engines 22 mo. while in war service. Member of maintenance crew of canning company during summer vacation. Part time maintenance work at University of Maine, 1950-51. War non-commissioned service in Army Air Force over 3 years. Married. Age 27. No disability. Available June 25. Salary open. W-219-51

NEW BOOKS

THE WATER AND THE POWER, by Albert N. Williams. Cloth, xiv+378 pages, 5½ x 8½ inches. Illustrated and indexed. Duell, Sloan and Pearce, Inc., (270 Madison Ave., New York 16, N. Y.). $4.50.

A readable popular treatment of water as a resource not to be taken for granted west of the 100th meridian. In addition to an introduction and two concluding chapters of general information and interpretations, separate chapters deal with each of five major river basins of the West, the Colorado, Sacramento and San Joaquin, Rio Grande, Missouri, and Columbia. In these the historic, economic and social development of the areas are interpreted in terms of water resource development and use. This work provides a condensed picture of many of the competing interests, viewpoints, and policies which are continuing important issues in the West.

Farm Mechanization Directory, 1951. First edition. Paper ix + 389 pages, 5½ x 8½ inches. Temple Press, Ltd. (Bowling Green Lane, London ECI) Six shillings net.

A guide for buyers of mechanical farm equipment throughout the world, covering primarily products available in the United Kingdom, and in most cases also manufactured there. It includes a list of British organizations interested in farm mechanization, an index of manufacturers, index of trade names, a classified directory, and an index to classifications.

Reflections
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half a century of experience,
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For perfection in your wheel design always specify TIMKEN® bearings

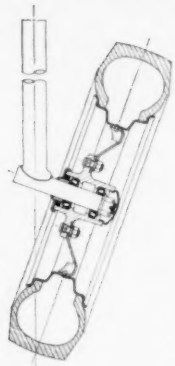

Fig. 1

When Timken bearings are specified for new agricultural designs, the manufacturer obtains the best bearing protection he can buy while the sales manager obtains another mark of quality that will make his selling job easier. In the proven wheel designs shown here, Timken bearings provide proper protection against radial, thrust and combination loads while the effective seals hold lubrication time and costs to a minimum.

In Figure 1, the close spacing of the Timken bearings in the wheel of a one-way disk plow allows shorter and lighter wheel hubs. Figure 2 shows how Timken bearings provide a light, compact, low-cost wheel hub design for a grain drill used in high-speed service.

Figure 3 illustrates the bearing design used for a pull-type combine wheel having a maximum load of about 2,000 pounds per wheel. The propelling axle plus the internal gear reduction design for the propelling wheel of a self-propelled combine appears in Figure 4.

An offset type of Timken bearing arrangement permitting a reduced axle diameter, lighter weights and lower costs is shown in the manure spreader wheel in Figure 5. The heavier requirements of high-speed tractor service resulted in the proven design of the hay rake caster wheel in Figure 6.

The tractor mower wheel design in Figure 7 incorporates a rubbing seal contact on the extended Timken bearing cone or inner race.

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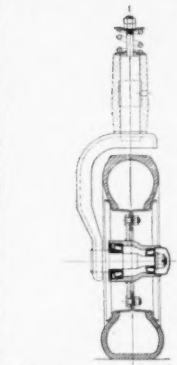

Fig. 7

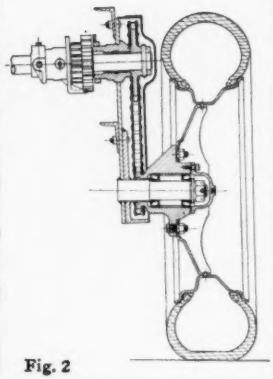

Fig. 2

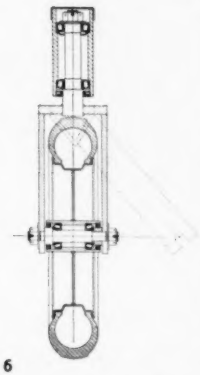

Fig. 6

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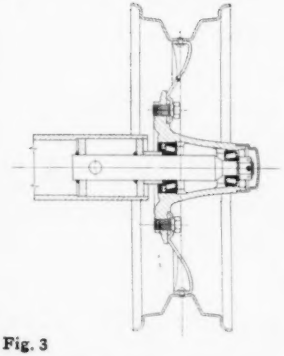

Fig. 3

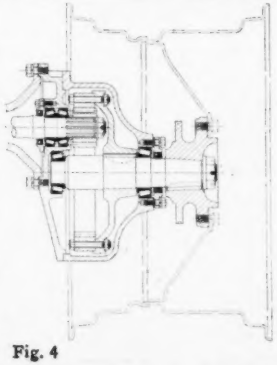

Fig. 4

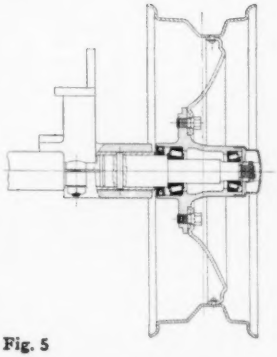

Fig. 5

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